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# **Hop Brook Lake, Connecticut Priority Pollutant Scan**

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August 1993



**US Army Corps  
of Engineers**  
New England Division

HOP BROOK LAKE  
CONNECTICUT  
PRIORITY POLLUTANT SCAN

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HOP BROOK LAKE  
PRIORITY POLLUTANT SCAN

1. SUMMARY

As part of NED's continuing program of priority pollutant scans at all projects, water and sediment samples were collected from Hop Brook Lake on 30 September 1991 and analyzed for metals, PCBs, pesticides, volatile and semi-volatile organics, and dioxins. Results showed mostly low to very low concentrations, although some parameters were at levels more typical of lightly contaminated conditions. However, no compounds were at levels harmful to aquatic life forms likely to live in Hop Brook Lake, or recreational users of the lake. Source of these substances was normal watershed activities.

Hop Brook Lake is a sink for fine-grained particulate matter. Because metals and organic compounds tend to bind to such particles, elevated levels are found in sediments from deeper places in the lake. Virtually all metals and organic compounds were in higher concentrations at lake station HB14 than discharge station HB05.

Results from this priority pollutant scan can be used as a reference when evaluating results from other studies.

2. AUTHORITY

This report is prepared in accordance with ER 1130-2-415, "Water Quality Data Collection, Interpretation, and Application Activities," dated 28 October 1976; and ER 1130-2-334, "Reporting of Water Quality Management Activities at Corps Civil Works Projects," dated 30 April 1987. These regulations establish guidelines for conducting and reporting water quality control management responsibilities at Corps Civil Works facilities.

3. PROJECT DESCRIPTION

a. Location. Hop Brook Lake is located in western Connecticut in the lower Naugatuck River subbasin of the Housatonic River Basin (figure 1). The lake was created in 1968 by a dam on Hop Brook, 1.3 miles above its confluence with the Naugatuck River and 3 miles southwest of Waterbury, Connecticut. The reservoir, or flood encroachment area, is partially within the towns of Middlebury, Waterbury, and Naugatuck, Connecticut. Total watershed area upstream from the dam is 16.4 square miles.

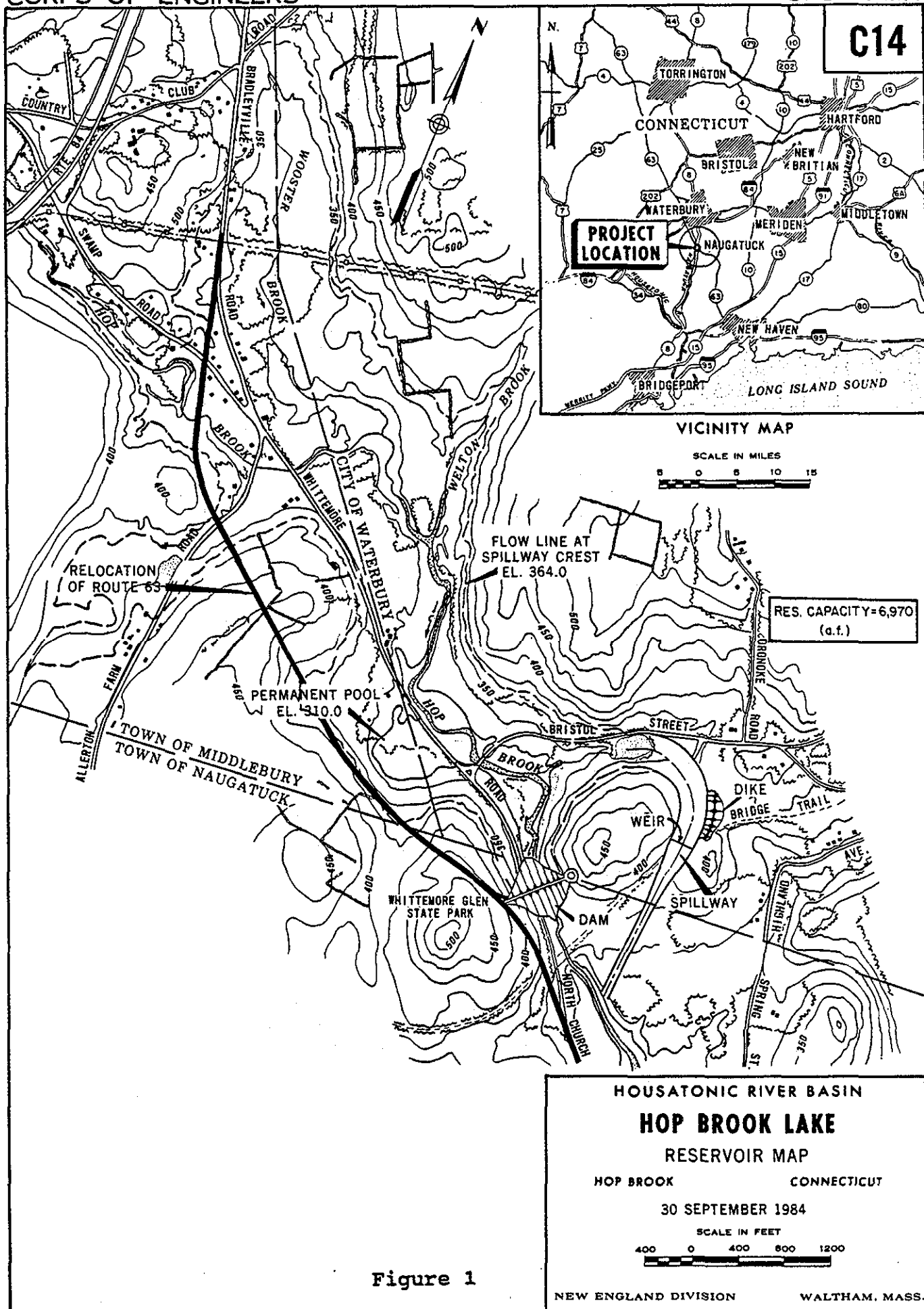


Figure 1

b. Purpose. The Corps of Engineers comprehensive flood control plan for the Naugatuck River basin consists of seven dams and reservoirs, and four local protection projects. As part of this program, Hop Brook Lake provides flood protection primarily to Naugatuck, Connecticut, and also to small towns downstream along the Naugatuck River as far as Derby, Connecticut. In addition to its primary purpose of flood control, the project is also used for recreation and fish and wildlife habitat. The project was completed in November 1968.

c. Recreation. A small 330 acre-foot permanent pool is maintained for swimming, fishing and small nonpower boating. Although the Hop Brook project is small with a total area of only 616 acres, it receives some of the highest recreational visitor usage of any NED project. However, the lake suffers from water quality problems, including chronic algae blooms and high coliform counts. These problems are believed to originate in a variety of upstream sources, including erosion from dairy farms, overflowing wastewater pumping stations, failing septic systems, and golf course runoff. Means to improve water quality at Hop Brook Lake is the subject of a multiyear study by NED that is summarized in "Hop Brook Lake Water Quality Study, Interim Report, January 1993," which was prepared by the Hydraulics and Water Quality Branch.

d. Water Quality Classification. Hop Brook has been designated a class B stream by the Connecticut Department of Environmental Protection (CTDEP). Class B waters are suitable for bathing and other recreational purposes, agricultural uses, certain industrial processes and cooling. Class B waters should be excellent fish and wildlife habitat, and have good aesthetic value.

#### PRIORITY POLLUTANT SCANS

Contaminants at Corps projects are of great concern to the Corps nationwide. In response to ETL 1110-2-281, "Reservoir Contaminants," dated 17 June 1983, and letter on "Potential Contamination of Corps Reservoirs," dated 3 June 1983, from Major General Wall, many Corps Divisions have tested for the full range of EPA priority pollutants at all projects. NED began priority pollutant scans in 1987 when the NED Lab achieved the ability to perform analyses for EPA organic priority pollutants. Hopkinton Lake and Birch Hill Dam were the initial projects studied in 1988. Additional projects included Northfield Brook Lake in 1989, Hop Brook Lake, and Thomaston Dam in 1991. NED intends eventually to perform

scans at all projects. Hop Brook Lake became a priority for this study because it is heavily used for recreation, and is being extensively studied to determine causes of algae blooms and high coliform bacteria counts which can limit recreational usage of the lake.

## SAMPLING STATIONS

Water and sediment samples were collected on 30 September 1991 by NED Environmental Laboratory personnel at stations HB14 and HB05. Station HB14, located at the deepest part of the lake, should contain very small particles which enter and settle in the lake. Because many compounds on the priority pollutant list attach strongly to fine sediments, it was important to sample a location likely to trap such material. Station HB05 is located below the dam and is typical of project discharge. Figure 2 shows sampling station locations.

## 6. ANALYSES

Analyses were performed by NED's Environmental Laboratory except for dioxins and furans which were analyzed by a validated contracting laboratory.

## 7. RESULTS AND DISCUSSION

a. General. Appendix A contains raw data results from the priority pollutant scan. Tables 1 through 5 contain summaries of substances found in detectable concentrations. Tables 6 through 46 (Appendix B) contain summaries of standards for parameters found in significant concentrations at Hop Brook Lake. Appendix B tables also contain concentrations of these parameters from other sites, as an aid in determining background concentrations.

(1) Detection Limits. The first step in evaluating data is to compare results to detection limits and concentrations found in the method blanks. Parameters occurring in less than detectable concentrations were assumed not to be a problem, unless the detection limit was high compared to the standard. Parameters in detectable concentrations were compared with levels in the method blank. Usually, concentrations in the blank were less than detectable; however, for some parameters, detectable amounts were reported for the blank. This was a sign of sample contamination. If the level in the sample was in the same range as that in the blank, it was considered a laboratory artifact.

(2) Water Quality Standards. Parameters found in concentrations significantly higher than in the blank, were

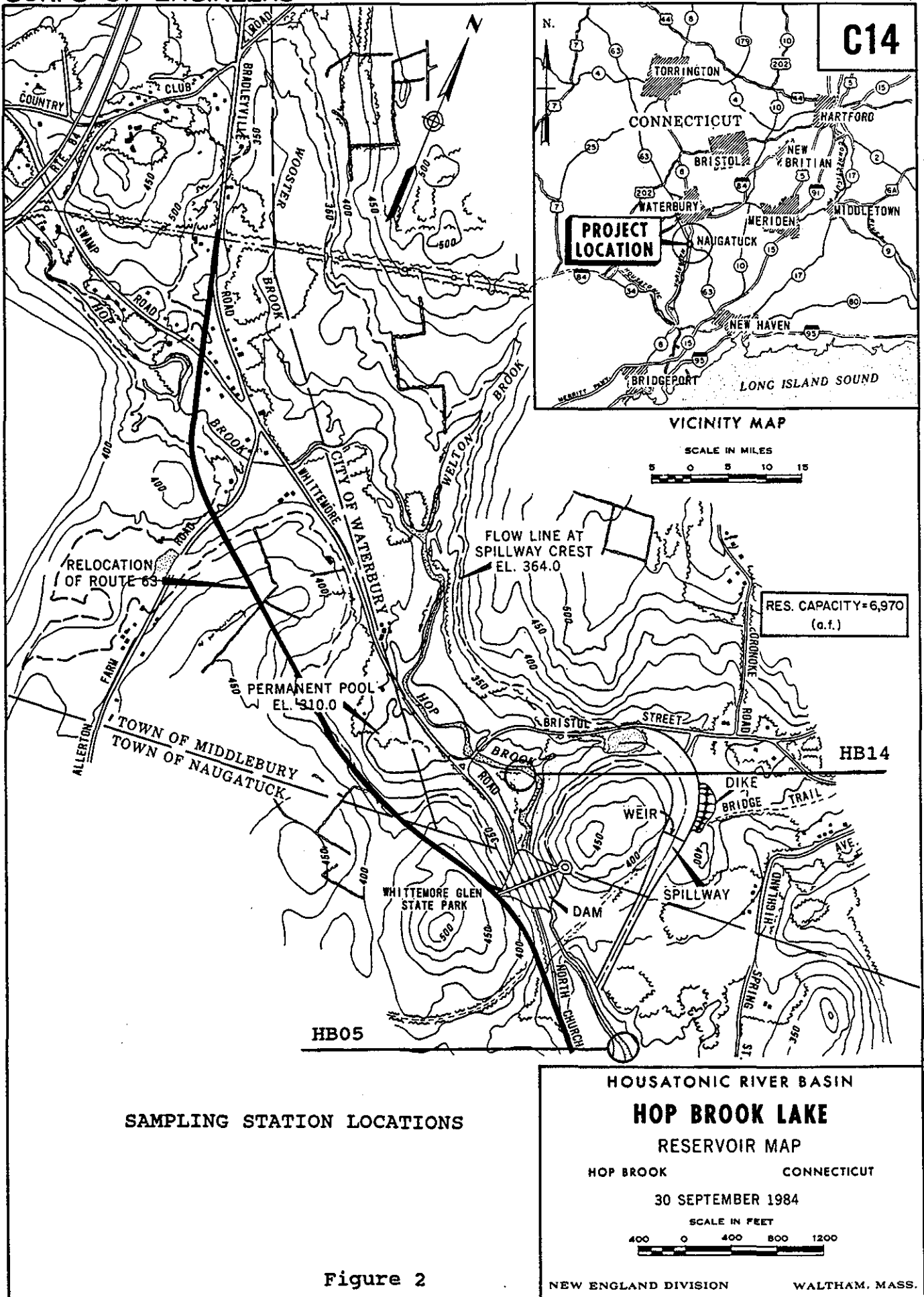


Figure 2

compared to standards for potable water and freshwater aquatic life, if such standards existed. For parameters with no criteria, lowest toxic concentrations (LTC) or lowest effect concentrations (LEC) were used as references, if available. Measured concentrations were then compared to levels at other locations, especially locations reported as contaminated or clean.

(3) Sediments. Standards have not been established for sediments the way they were for water (EPA is reportedly working on draft sediment quality criteria for six parameters; however, we have verified this). EPA developed guidelines for pollutional classification of Great Lakes harbor sediments in 1977; however, these dealt with only 10 metals and no organic compounds other than TKN. The Massachusetts Coastal Zone Management Agency developed criteria for disposal of dredged sediments (Barr, 1987). These guidelines classified dredged material into three categories from type I which was clean, to type III which was contaminated. Although useful, these numbers were developed only for PCBs and nine metals. The State of Washington developed criteria, for 47 metals and compounds in sediments, including "Sediment Quality Standards" which identify surface sediments that have no adverse effects on biological resources, and "Sediment Cleanup Standards" which are the maximum degree of contamination allowed after cleanup. NOAA developed indices for potential biological effects of sediment-sorbed contaminants for a number of metals, pesticides, and PAHs (Long and Morgan, 1990). These indices were the ER-L, ER-M, and AET, which are explained in the following paragraphs. Finally, measured concentrations were then compared to levels at other locations, especially sites reported as contaminated or clean.

(4) ER-L and ER-M. As explained in NOAA Technical Memorandum NOS OMA 52, The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program, by E.R. Long and L.G. Morgan, ER-L and ER-M are statistically derived measures of sediment pollutant concentrations having effects on sensitive aquatic life. ER-L was a concentration at the low end of the range in which effects were observed; ER-M was a concentration approximately midway in the range of reported values associated with biological effects. As explained by Long and Morgan, "These values were determined using a method similar to that used by Klapow and Lewis (1979) in establishing marine water quality standards for the State of California. For each chemical of interest, they assembled available data from spiked-water bioassays, examined the distribution of the reported LC50 values, and determined the lower 10- and 50-percentile concentrations among the ranges of values. In the present



document, the ER-L values were concentrations equivalent to the lower 10 percentile of the screened available data, and indicated the low end of the range of concentrations in which effects were observed or predicted. They were used in the document as the concentrations above where adverse effects may begin, or predicted among sensitive life stages and/or species or as determined in sublethal tests. The ER-M values for the chemicals were the concentrations equivalent to the 50 percentile point in the screened available data. They were used in the document as the concentration above where effects were frequently, always observed, or predicted among most species."

(5) AET. As explained by Long and Morgan, "An AET concentration is the sediment concentration of a selected chemical above which statistically significant ( $P \leq 0.05$ ) biological effects (e.g., depressions in the abundance of benthic infauna or elevated incidence of mortality in sediment toxicity tests) always occur and, therefore, are always expected."

(6) Washington State Sediment Standards. In response to concerns about contamination in Puget Sound, the State of Washington developed criteria, for 47 metals and compounds in sediments (Ginn and Pastorok, 1992). These included "Sediment Quality Standards" which identify surface sediments that have no adverse effects on biological resources, and "Sediment Cleanup Standards" which are the maximum degree of contamination allowed after cleanup. Criteria for metals are on a dry weight basis. However, criteria for nonpolar organic compounds represent concentrations "normalized" on a total organic carbon basis. To normalize to total organic carbon, the dry weight concentration for each parameter is divided by the decimal fraction representing the percent total organic carbon content of the sediments. For example, the sediment quality standard for naphthalene is 370 ppm. If the measured concentration of naphthalene in a sediment sample is 37 ppm, and the TOC concentration in the sediment is 10 percent, then the normalized naphthalene concentration for this sample is 37 divided by 0.1 = 370 ppm. Therefore, this sample would be equal to the sediment quality standard. TOC is important in computing sediment standards because mobility of these compounds is decreased by organic matter in the sediments. These standards can be modified by site-specific bioassay testing. Data on the organic carbon content of Hop Brook sediments is not available. Consequently, levels were estimated from results at other NED projects. At Birch Hill Dam, a NED project in central Massachusetts, percent volatile solids ranged from 25.6 in a "poorly graded sand with silt" to 1.3 in a "poorly

graded sand" (NED, 1992c). The sampling stations at Hop Brook Lake were chosen to have a high percentage of fine-grained material since these are likely to have higher levels of many contaminants. Station HB14, in particular, is a trap for fine-grained sediment which is often high in organic carbon content. Therefore, to compare contaminant levels at Hop Brook Lake to Washington sediment standards, organic carbon content of station HB14 is assumed to be 20 percent, and content at station HB05 is assumed to be 10 percent. Actual carbon concentrations are likely higher; however, use of these numbers will give conservative results.

b. PCBs. Table 6 in appendix B summarizes standards and data for PCBs.

No detectable levels of PCBs were found in water samples and only low levels were found in soil samples. At station HB05, 0.020 ppm was found in the sediment sample, and 0.090 ppm was measured at station HB14; the blank sample had less than 0.0025 ppm. These levels do not indicate a health threat and are well within the range reported for background conditions. Table 6 (Appendix B) contains a summary of standards and data for PCBs.

Acute toxicity of PCBs in water to freshwater aquatic organisms probably occurs only at concentrations above 2 ppm (EPA, 1986).

Background levels of PCBs in soils have been variously reported as 0.002 to 0.5 ppm. "PCB Pollution in the New Bedford, Massachusetts Area, A Status Report" states: "There is great regional variation in the degree of PCB contamination in freshwater sediments throughout the United States. The highest PCB levels are in industrial areas, particularly in the eastern part of the country. The area from the Pacific coast to the Continental Divide has the lowest PCB level in sediments ranging from 0.0022 to 0.020 ppm. The highest 'background' values reported are in the Appalachian Mountain-Atlantic coast region where sediments with values ranging from 0.1 to 0.5 ppm have been found" (MCZM, 1983). Bidelman et al. (1981) reported finding 0.0026 ppm in sediments a South Carolina marsh; they attributed these entirely to atmospheric deposition.

In marine sediments, PCB levels less than 0.5 ppm indicate dredged material is "clean fill" according to the Massachusetts Coastal Zone Management (Barr, 1987). Guidelines for the Pollutational Classification of Great Lakes Harbor Sediments classify sediments with less than 1 ppm as unpolluted (EPA, 1977). The State of Washington set sediment

quality standards of 12 ppm total PCBs and sediment cleanup standards of 65 ppm (Ginn and Pastorok, 1992).

On the other hand, Long and Morgan (1980) report: "It appears that biological effects may begin in association with PCB concentrations above about 0.003 ppm." They report an ER-L of 0.050 and an ER-M of 0.4 ppm.

Neither EPA nor CTDEP have established criteria for PCBs in sediment. The State of Washington set sediment quality standards of 12 ppm and sediment cleanup standards of 65 ppm PCBs (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14, and 10 percent at station HB05, the sediment quality standards become 2.4 and 13, and cleanup standards become 1.2 and 6.5 ppm for HB14 and HB05, respectively.

PCBs were measured in sediments at three other NED projects: Birch Hill Dam in Massachusetts, Thomaston Dam in Connecticut, and Otter Brook Lake in New Hampshire. Birch Hill Dam has sediments contaminated with PCBs up to 250 ppm. Sources of these PCBs are believed to be past papermill effluents. Sediments at Thomaston Dam represent lightly contaminated conditions due to urban development and upstream discharges in its watershed; at present the river is fairly clean, but 15 or more years ago, discharges were poorly treated and the river was polluted. However, "lightly contaminated" refers to the overall condition of the sediments and not necessarily to levels of PCBs. PCB levels in two sediment samples ranged from 0.068 to 0.27 ppm (NED, 1992b). Otter Brook's sediments are typical of clean background conditions due to the low level of development in its watershed. At Otter Brook Lake, the concentration at one station was less than detectable (<0.0043 ppm), and at the other, the measured concentration was 0.017 ppm (NED, 1992).

In sum, it appears that measured PCB concentrations in Hop Brook soils are typical of background concentrations. Such levels may be high enough to have effects on organisms, but are not toxic and are well below levels requiring cleanup or remediation.

c. Dioxins and Furans. No detectable levels of furans were measured at Hop Brook Lake, and the only form of dioxin in measurable quantities was 2.9 ppb of octachlorodibenzo-dioxin. Although this level is somewhat elevated for uncontaminated sediments, it is within the range observed for urban area soils without known sources of dioxin. This level does not represent a health threat either from contact with the material, or from consumption of fish from the area.

Dibenzodioxins (dioxins) and dibenzofurans (furans) usually occur in the environment as a complex mixture of related isomers and congeners. Both arise as byproducts of processes, producing PCBs and other chlorinated organic compounds. Principal sources include various industrial processes (including paper manufacturing), incinerators, and forest fires. Dioxins and furans are ubiquitous in the environment, but are usually detected only in very low concentrations in the air or surface waters. These compounds are hydrophobic and adsorb strongly to sediments or suspended material, especially fine particle materials. These compounds are resistant to biodegradation, and bioconcentration in aquatic organisms has been demonstrated. Photolysis occurs in the atmosphere and, in combination with volatilization from the soil, may be the major natural destruction method (HSDB, 1993).

There are five forms of dioxin: tetra-, penta-, hexa-, hepta-, and octachlorodibenodioxin. As reported by Kamrin and Rodgers (1985), and Travis et al. (1989), tetrachlorodibenzodioxin (TCDD) is the most harmful and octachlorodibenodioxin (OCDD) is the least toxic form. TCDD is generally found at the lowest levels, while OCDD is typically found at concentrations 1 to 2 orders of magnitude higher.

Table 7 (Appendix B) contains data summaries on dioxins and furans. No criteria have been established for dioxins or furans in drinking water, to protect freshwater aquatic life, or for sediments.

Concentrations of TCDD in most uncontaminated soils are below the detection limit of 0.0002 ppb (Nestrick et al.); however, soils from 15 urban sites in the United States with no obvious sources of contamination had combined dioxin plus furan (PCDD/PCDF) concentrations ranging from 0.05 to 9.1 ppb (Travis et al. 1989). Western Lake Ontario sediment cores contained measurable TCDD levels of 0.003 to 0.013 ppb (Hallett and Brooksbank). PCDD/PCDF levels of less than 1 ppb were found in rural locations of Michigan, suggesting that atmospheric transport may carry PCDD/PCDF to remote locations. Kamrin and Rodgers (1985) reported that mean concentrations of PCDD/PCDF in sediment samples from unpolluted Lakes Huron, Michigan, and Siskiwit ranged from 0.56 to 0.9 ppb; mean concentrations of OCDD in Lake Huron were 0.87 ppb and Lake Michigan were 0.90 ppb. Because of the equivalence of the mean Lake Huron and Michigan sediment concentrations, source of these PCDD/PCDF was concluded to be atmospheric precipitation. Lake Zurich had mean sediment concentrations of 1.7 ppb PCDD/PCDF, also due to atmospheric precipitation. Hashimoto et al. (1990) reported finding dioxins in 8,120 year old

sediments at concentrations up to 0.4 ppb, indicating their presence before industries developed.

Concentrations of TCDD from six storm sewer and creek sediment samples from the Love Canal chemical dump site area in Niagara Falls, New York, ranged from 0.9 to 312 ppb (Smith, R.M. et al. 1983). Analyses of soil from horse show arenas in rural Missouri, where dioxin-contaminated oil was sprayed to control dust, showed 31,800 to 33,000 ppb TCDD (IARC, 1977). Soil samples from Times Beach, Missouri, in 1985, which had been sprayed with TCDD-contaminated waste oils in the early 1970s, contained 0.8 to 196 ppb (Freeman, R.A. et al. 1986). Kamrin and Rodgers (1985) reported PCDD/PCDF levels of 3,000 ppb in soils in Midland, Michigan, close to chemical waste combustion sources.

Dioxins and furans have been measured at two other NED projects: Thomaston Dam, Connecticut, and Birch Hill Dam, Massachusetts. No detectable levels of PCDDs or PCDFs were found at Thomaston Dam, with detection limits of 0.65 ppb for OCDD and 0.016 ppb for TCDD (NED, Feb. 1992). Aquatic sediments within the Birch Hill reservoir contain somewhat elevated levels of dioxins and dibenzofurans (NED, 1992c), which was not surprising since these sediments are contaminated with PCBs (NED, 1989). Highest detected level of any isomer was 11 ppb OCDD. Maximum detected total PCDD/PCDF concentration was 13.8 ppb. These compounds were presumably discharged, along with PCBs, from paper mills situated on the Otter River upstream of the reservoir. The only compound detected in background samples was 0.41 ppb OCDD which was found at 1 of 2 control sites.

Because of their hydrophobic nature, the trace amounts normally found in the environment, and the expense of such analyses, no water samples were analyzed for dioxins or furans. Because of the expense, only sediment from station HB14 was analyzed. Station HB14 has the smallest sized sediment particles; consequently, it is the most likely location for these contaminants to be found. No detectable levels of polychlorinated dibenzofurans (furans) were found, and only 1 of 5 types of dibenzodioxins (dioxins) were noted. Table 1 summarizes results of dioxin and furan analyses.

The only detectable form of dioxin at Hop Brook Lake was OCDD, measured at 2.9 ppb in sediment from station HB14. The detection limit for this analysis was 0.042 ppb. Although somewhat elevated compared to most background sites, it is within the range that has been found in uncontaminated urban soils. Maximum OCDD levels in Hop Brook sediments were only about three times higher than the mean sediment concentrations in Lakes Huron and Michigan, and the source of OCDD in

TABLE 1

DETECTABLE CONCENTRATIONS AT HOP BROOK LAKE  
PCBS, DIOXINS, AND PESTICIDES

<u>Parameter</u>	<u>Station</u>	<u>Media</u>	<u>Concentration</u>	
			<u>Sample</u> (ppb)	<u>Blank</u> (ppb)
<u>PCBs</u>				
Total PCBs	HB14	Soil	90	<2.5
	HB05	Soil	20	<2.5
<u>Dioxins</u>				
Octachlordibenzodioxins	HB14	Soil	2.9	<0.042
<u>Pesticides</u>				
4,4'-DDE	HB14	Soil	15	<4
4,4'-DDD	HB14	Soil	17	<4
4,4'-DDT	HB14	Soil	26	<4
	HB05	Soil	12	<4

these lakes was suspected of being atmospheric deposition. Travis et al. (1989) report that concentrations in urban air of PCDDs and PCDFs are remarkably similar in all industrialized countries.

Dioxin levels at Hop Brook Lake appear to be typical of urban soils. Although the OCDD level was somewhat above mean levels for uncontaminated soils, it is within the range observed for urban United States soils without an obvious source of contamination. Hop Brook Lake is surrounded by urbanized areas and is sort of an urban park. Also, station HB14 is a trap for fine sediment particles and the location expected to have the highest concentrations of dioxins and furans. At Birch Hill Dam, a maximum of 11 ppb OCDD was found in sediments; fish from that area had elevated levels of dioxin, but did not exceed FDA advisories (Penko, 1992). Consequently, it is unlikely fish at Hop Brook Lake would be unsafe for human consumption. Dioxin levels at Hop Brook Lake should have a high priority for a repeat monitoring, but are not otherwise a concern.

d. Pesticides. No detectable levels of pesticides were found in water samples, but DDT and its metabolites (DDE and DDD) were found in sediment samples. Levels detected were somewhat elevated, probably because of agricultural activities in the watershed. However, concentrations were not high enough to indicate unusual or harmful conditions.

(1) 4'4' DDT. Table 8 in appendix B summarizes standards and data for 4'4' DDT.

In 1972, DDT was banned for general use in the United States. There are no natural sources, so its presence indicates residuals from past insecticidal sprayings, or atmospheric deposition. DDT is hydrophobic and absorbs very strongly to sediments, especially fine-grained and organic sediments. It bioconcentrates in higher organisms, and is biodegradable; however, its biodegradation products, DDD and DDE, may be resistant to further biodegradation. DDT at soil surfaces may volatilize and photodegrade (HSDB, 1993).

At Hop Brook Lake, 12 ppb were measured at station HB05 and 26 at station HB14. The method detection limit for the blank was 4 ppb.

There are no standards for DDT in drinking water. EPA has set criteria to protect sensitive aquatic organisms from DDT and its metabolites in water at 1.1 ppb for acute conditions and 0.0010 ppb for chronic conditions (USEPA, 1976). However, EPA has proposed changing these to 0.0067

ppb for chronic conditions and 0.021 for acute. In addition, EPA proposes to set a standard for DDT alone at 0.00023 ppb for chronic conditions and 0.41 for acute conditions (HSDB 1993).

There are no standards for DDT in soils or sediments. Long and Morgan (1990) report apparent effects thresholds for DDT in marine sediments ranging from 3.9 to greater than 270 ppb. They report an ER-L of 1 and an ER-M of 350 ppb. The sediment safe level, based upon sediment/water partitioning coefficients (at 1 percent TOC), was 210 ppb for acute water quality criteria and 1.6 ppb for chronic water quality criteria.

DDT measurements at other NED projects did not find detectable concentrations in water. However, at Thomaston Dam in Connecticut, sediments were analyzed for DDT at two stations; results found about 6.6 ppb at one and 27 ppb at the other (NED, 1992b). At Otter Brook Lake in New Hampshire, sediments at two stations were examined, and both had less than detectable levels with detection limits of 6.4 to 6.9 ppb (NED, 1992).

Staples et al. (1985) examined the EPA STORET data base for the period 1980-83 and found 1,139 sediment or soil samples analyzed for DDT. Of these, 53 percent contained detectable concentrations and the median was 0.1 ppb.

Two researchers examined sediments from Lake Michigan. Schacht (1974) measured DDT in samples near Illinois, and found 0.11 to 13 ppb. Leland et al. (1973) found a median of 9.3 ppb in surficial sediments from southern Lake Michigan.

The U.S. Nation Soils Monitoring Program from 1976 to 1980 found 13.2 percent of samples had detectable levels of DDT, with a maximum of 110.6 ppb. During FY93, 1,483 samples were examined; 18.5 percent had detectable levels ranging from 10 to 18,930 ppb with a mean of 130 ppb (Carey et al. 1979). In 1971, 345 samples of urban soils from five cities were analyzed; 62.9 percent had detectable concentrations ranging from 10 to 5,860 ppb (Carey et al. 1979b). Samples of fields with regular pesticides use found 290 to 15,630 ppb in vegetable and cotton fields, 70 to 245,000 ppb in fruit tree orchards, and 10 to 9,230 ppb in fields used for small grain and root crops (Stevens et al. 1970).

A study of sediments in cisterns in the United States and British Virgin Islands found 31.4 percent had detectable levels of DDT, ranging from 90 to 271,000 ppb with a median



of 2,770 ppm (Lenon et al. 1982). These high levels were likely due to aerial spraying for mosquitos.

DDT levels in Hop Brook sediments are somewhat elevated above expected background conditions for uncontaminated U.S.A. soils. Levels are above the ER-L, ER-M, and AET; consequently, some adverse effects would be expected on sensitive aquatic organisms in contact with these sediments. However, there are no acute hazards, and levels measured at Hop Brook are within the range found at other NED projects, and are far below the range found in soils where DDT was used as an insecticide. The likely source of this DDT is agricultural areas in headwaters of the watershed. DDT is likely carried into the project area on eroded soil washed off upstream farms.

(2) 4'4' DDE. Table 9 in Appendix B summarizes standards and data for 4'4' DDE.

DDE is an impurity in, as well as a metabolic breakdown product of DDT, and found in the environment as a result of DDT usage as an insecticide. There are no natural sources of DDT, and its use has been banned since the 1970s; therefore, any traces of DDT or DDE are residuals from earlier usage. DDE absorbs strongly to sediments, particularly fine grained or organic ones. Consequently, it is rarely found in detectable concentrations in water. DDE does not readily volatilize from soils, but is subject to photolysis if exposed to sunlight. It bioconcentrates, but biodegrades very slowly, if at all (HSDB, 1993).

No detectable level of DDE was found in sediments at station HB05 using a detection limit of 6.5 ppb; however, 15 ppb were measured at station HB14.

There are no standards for DDE or DDT in drinking water. EPA has set criteria to protect sensitive aquatic organisms from DDT and its metabolites in water, at 1.1 ppb for acute conditions and 0.0010 ppb for chronic conditions (USEPA, 1976). However, EPA has proposed changing these to 0.0067 ppb for chronic conditions and 0.021 for acute (HSDB, 1993).

There are no standards for DDE in soils or sediments. Long and Morgan (1990) report apparent effects thresholds for DDE in marine sediments ranging from 2.2 to 15 ppb. They report an ER-L of two and an ER-M of 15 ppb. The sediment safe level, based upon sediment/water partitioning coefficients and acute water quality criteria, was 7,000 ppb.

DDE measurements at other NED projects did not find detectable concentrations in water. However, at Thomaston Dam in Connecticut, sediments were analyzed for DDE at two stations and results found 8.4 ppb at one, and less than detectable levels at the other, with a detection limit of 16 ppb (NED, 1992b). At Otter Brook Lake in New Hampshire, one station had approximately 1.4 ppb, and the second station had less than detectable levels, with a detection limit of 6.9 ppb (NED, 1992).

The U.S. National Monitoring Program, between 1976 and 1980, tested soil and sediment samples across the country and found that 22.7 percent had detectable levels of DDE with a maximum of 163 ppb (Carey and Kutz, 1985). In FY73, 1,483 soil and sediment samples from 37 states were tested; 20.2 percent had detectable levels of DDE with a range of 10 to 7,160 ppb and an average of 50 ppb (Carey et al. 1979). In FY72, 1,486 soil and sediment samples from 37 states were tested; 20.2 percent had detectable levels of DDE with a range of 10 to 54,980 ppb and an average of 110 ppb (Carey et al. 1978).

In 1985, the U.S. Environmental Protection Agency's STORET data base contained 1,047 soil or sediment samples analyzed for DDE. Of these, 60 percent contained measurable levels with a median concentration of 0.1 ppb (Staples et al.).

Bidelman et al. (1981) examined atmospheric deposition of DDT in marshes at North Inlet on the coast of South Carolina. Although DDT was not applied to these soils, they received significant atmospheric inputs. The area between Cape Fear, North Carolina, and the Florida Keys is downwind of southern cotton growing States. Until banned in 1972, these States used large amounts of DDT. Using samples collected in 1974-75, Bidelman found an average concentration of DDT and its metabolites of 0.0008 ppb in rain and 3.4 ppb in sediment.

Gooschenko, et al. (1976) measured DDE in sediments at 34 stations in the upper Great Lakes. Detectable concentrations were found in 38 percent of the samples, with a range of 2 to 7 ppb.

The Ohio Valley Water Sanitation Commission (1978) examined 10 rivers and streams and 16 locations along the Ohio River for DDE in sediments. Detectable concentrations were found in 10 percent of the stream sediments and 25 percent of the Ohio River sediments. The range of detectable concentrations was 1.1 to 4.1 ppb.

Sediments from the Illinois waters of Lake Michigan were examined by Schacht (1974); he found a range of 0.06 to 4.82 ppb with a mean of 1.2 ppb.

Frank et al. (1976) tested soils in Ontario orchards that had been sprayed with DDT, and found 20 to 33,300 ppb with an average concentration of 4,300 ppb.

The maximum concentration of 15 ppb of DDE in sediments at Hop Brook Lake at station HB14 is well below the 7,000 ppb that would cause acute water quality criteria to be exceeded based on sediment-water partitioning. On the other hand, the 15 ppb DDE at this station is equal to the ER-M developed by Long and Morgan. This indicates that some adverse effects on aquatic life would be expected for sensitive organisms exposed to these sediments. However, station HB14 is the bottom of the deepest hole in Hop Brook Lake and few organisms are exposed to these sediments. Because of anaerobic conditions in this hole, any organisms exposed to these sediments would be pretty hardy. Also, it should be noted that 15 ppb is around the detection limit for DDE; e.g., at Thomaston Dam, analyses for one sediment had a detection limit of 16 ppb. Finally, it should be remembered that DDE very strongly adsorbs to fine-grained sediments and station HB14 is a trap for such particles; consequently, sediments at HB14 are expected to have the highest levels of DDE in the lake. On the whole, the level at HB14 was somewhat elevated, but DDE levels in Hop Brook Lake are low and not a cause for concern.

(3) 4'4' DDD. Table 10 in appendix B summarizes standards and data for 4'4' DDD.

DDD was used as an insecticide before it was banned in the early 1970s, and is a metabolic breakdown product of DDT. There are no natural sources of DDD; therefore, any traces of DDD are residuals from earlier uses. DDD absorbs strongly to sediments, particularly fine grained or organic ones. Consequently, it is rarely found in detectable concentrations in water. DDD does not readily volatilize from soils, but is subject to photolysis if exposed to sunlight. It bioconcentrates, but biodegrades very slowly if at all (HSDB, 1993).

No detectable level of DDD was found in sediments at station HB05 using a detection limit of 6.4 ppb; however, 17 ppb were measured at station HB14.

There are no standards for DDD or DDT in drinking water. EPA has set criteria to protect sensitive aquatic

organisms from DDT, and its metabolites in water, at 1.1 ppb for acute conditions and 0.0010 ppb for chronic conditions (USEPA, 1976). However, EPA has proposed changing these to 0.0067 ppb for chronic conditions and 0.021 for acute (HSDB, 1993).

There are no standards for DDD in soils or sediments. Long and Morgan (1990) report apparent effects thresholds for DDD in marine sediments ranging from 2 to 43 ppb, and report an ER-L of two and an ER-M of 20 ppb. The sediment safe level based upon sediment/water partitioning coefficients (at 1 percent TOC) was 3,250 ppb for acute water quality criteria.

DDD measurements at other NED projects did not find detectable concentrations in water. However, at Thomaston Dam in Connecticut, sediments were analyzed for DDD at two stations and results found 9.1 ppb at one, and 24 ppb at the other (NED, 1992b). At Otter Brook Lake in New Hampshire, one station had 8 ppb, and the second station examined had less than detectable levels with a detection limit of 6.9 ppb (NED, 1992).

The U.S. Rivers National Water Summary of 1984 reported that bed material collected at sites between 1975-80, contained detectable levels of DDD in 31 percent of the 171 sites and 12 percent of the 990 samples examined (Harris and Sans, 1971).

In FY92, the U.S. National Soils Monitoring Program examined 1,487 samples from 37 States and found 7.8 percent had detectable levels of DDD, ranging from 10 to 38,460 ppb with a mean of 50 ppb (Feltz, 1980). In FY71, 380 samples were examined from five cities. All cities had detectable levels, and 42 percent of the 380 samples had 10 to 6,570 ppb with an average of 100 ppb (Carey et al. 1978). Another study of 50 samples taken from each of eight cities found detectable levels in 18 to 84 percent, an overall range of 10 to 5,060 ppb, and an overall average of 120 ppb (Wiersma et al. 1972).

Staples et al. (1985) examined the U.S. EPA STORET data base and found that of 1,087 samples analyzed for DDD, 60 percent had detectable levels with a median of 0.2 ppb.

The DDD content of undisturbed sediments off the southern coast of California was examined by Callahan et al. (1979). By means of radio dating of the sediment layers, they determined DDD began to appear around 1955 at 12 ppb and attained 18 ppb levels by 1976.

Two researchers examined Lake Michigan sediments for DDD. Schacht (1974) found 0.01 to 12.6 ppb with a mean of 3.04 ppb, and Carey et al. (1980) found 0.02 to 5.47 ppb with a mean of 1.01 ppb.

Gilliom, (1985) examined 25 samples at 13 sites in the Potomac River Basin, and 52 percent had detectable levels of DDD ranging from 0.8 to 640 ppb, with an average of 104 ppb.

Carey et al. (1980) examined United States rice growing areas in five States and found detectable levels of DDD in all samples, with a range of 10 to 940 ppb and an average of 50 ppb. A study of Japanese field soils found 18 to 1,554 ppb (Suzuki et al. 1974).

The maximum concentration of 17 ppb of DDD in sediments at Hop Brook Lake at station HB14 is well below the 3,250 ppb that would cause acute water quality criteria to be exceeded, based on sediment-water partitioning. On the other hand, 17 ppb DDD at this station is greater than the 2 ppb ER-L developed by Long and Morgan; although less than the 20 ppb ER-M. This indicates that some adverse effects on aquatic life would be expected for sensitive organisms exposed to these sediments. However, station HB14 is the bottom of the deepest hole in Hop Brook Lake and few organisms are exposed to these sediments. Because of the anaerobic conditions in this hole, any organisms exposed to these sediments would be pretty hardy. The maximum of 17 ppb DDD at Hop Brook Lake was within the range observed at Thomaston Dam in Connecticut, which had 9.1 to 24 ppb in the two stations where sediment samples were analyzed. Also, the maximum at Hop Brook Lake was not much above the 8 ppb maximum measured at Otter Brook Lake in New Hampshire. Finally, the maximum measured at Hop Brook Lake is well within the range of median levels observed in soils across the United States by various researchers. On the whole, the level at HB14 is somewhat elevated, but levels of DDD in Hop Brook Lake are not a cause for concern.

e. Trace Metals in Soil. Table 2 is a summary of soil metal analyses at Hop Brook Lake. There are no Federal or State criteria for bulk metal levels in soils. Most metals analyzed were found in detectable concentrations in soils, which would be expected. Aluminum, iron, and magnesium were found in highest concentrations, a condition typical of New England soils. All metal levels were higher at lake station HB14 than river station HB05 due to HB14's action as a trap for fine-grained sediment. Metals in water tend to bind to particulate matter, especially organic matter, making the

TABLE 2

DETECTABLE CONCENTRATIONS AT HOP BROOK LAKE  
TRACE METALS IN SOIL

<u>Parameter</u>	<u>Station</u>	<u>Media</u>	<u>Concentration in PPM</u>	
			<u>Sample</u> (ppm)	<u>Blank</u> (ppm)
Aluminum	HB14	Soil	34,000	<0.6
Aluminum	HB05	Soil	3,500	
Antimony	HB14	Soil	J68	<0.9
Antimony	HB05	Soil	J3.1	
Arsenic	HB14	Soil	2.2	<0.5
Arsenic	HB05	Soil	0.88	
Barium	HB14	Soil	210	<0.2
Barium	HB05	Soil	18	
Beryllium	HB14	Soil	1.8	<0.4
Beryllium	HB05	Soil	0.17	
Cadmium	HB14	Soil	3.4	<0.5
Cadmium	HB05	Soil	<0.5	
Calcium	HB14	Soil	3,200	<0.5
Calcium	HB05	Soil	1,500	
Chromium	HB14	Soil	48	<1.5
Chromium	HB05	Soil	J4.6	
Cobalt	HB14	Soil	J20	<0.2
Cobalt	HB05	Soil	J3.0	
Copper	HB14	Soil	39	<0.6
Copper	HB05	Soil	13	
Iron	HB14	Soil	44,000	<1.3
Iron	HB05	Soil	9,800	
Lead	HB14	Soil	58	<0.3
Lead	HB05	Soil	16	
Manganese	HB14	Soil	810	<0.5
Manganese	HB05	Soil	95	
Magnesium	HB14	Soil	8,700	<14
Magnesium	HB05	Soil	1,700	
Mercury	HB14	Soil	0.12	<0.03
Mercury	HB05	Soil	<0.03	
Nickel	HB14	Soil	J31	<3.5
Nickel	HB05	Soil	J5.1	
Potassium	HB14	Soil	6,100	<8.5
Potassium	HB05	Soil	750	
Silver	HB14	Soil	10	<1.3
Silver	HB05	Soil	<1.3	
Sodium	HB14	Soil	250	<2.2
Sodium	HB05	Soil	96	
Zinc	HB14	Soil	280	<0.5
Zinc	HB05	Soil	33	

J - Estimated value--analyte detected at less than  
the practical quantitation limit

finding of higher metal levels at HB14 unsurprising. While levels of metals at HB05 were low and indicative of unpolluted conditions, levels of barium, chromium, copper, iron, lead, nickel, silver, and zinc at station HB14 were in the range of moderately polluted to polluted sediments by some criteria. However, elevated levels of these metals were due more to the concentrating action of station HB14 as a sediment trap than an indication of heavy metal contamination in the watershed.

(1) Aluminum. Table 11 in Appendix B summarizes standards and data for aluminum.

One of the most common elements in the earth's crust, aluminum is an average of 8 percent of crustal rocks (80,000 ppm). Krauskopf (1979) reported that the average abundance in shale was 92,000 ppm; however, soils at Hop Brook Lake probably have only minimal shale content. Kesler-Arnold and O'Hearn (1990) found background levels in Lower Michigan soils had a range of 400 to 17,600 ppm and a mean of 4,900 ppm.

Analyses at other NED projects found similar levels. Two samples at Thomaston Dam in Connecticut had 6,500 to 11,000 ppm (NED, 1992b), and Otter Brook Lake in New Hampshire, had 7,400 to 18,000 (NED, 1992).

Criteria for aluminum in freshwater were derived from procedures described in "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses." These indicate that freshwater organisms and their uses should not be harmed, when the pH is between 6.5 and 9.0, if the 4-day average concentration of aluminum does not exceed 87 ug/L and the 1-hour average concentration does not exceed 750 ug/L more than once every three years on the average (FR, 1988). No criteria were estimated for pH outside this range.

With a maximum of 34,000 ppm, aluminum concentrations in Hop Brook soils are somewhat high, but still within the range of normal soils. The chemistry of aluminum in water is complex. Although never found naturally in the elemental form, it forms both soluble and insoluble salts. Generally, insoluble salts predominate. As long as the aluminum remains insoluble, it is harmless; however, soluble aluminum ions can be harmful to plants and aquatic organisms. Because only trace concentrations were found in water and aluminum is a major component of the minerals forming most soils, virtually all of the aluminum soil is most likely in insoluble forms. In sum, aluminum levels in Hop Brook Lake

soils appear to be within the range of normal soil levels and not a problem at this project.

(2) Antimony. Table 12 in Appendix B summarizes standards and data for antimony.

This silvery-white metal is rarely found pure in nature, and usually only in insoluble compounds (McKee and Wolf, 1963). Average concentration in the earth's crust is about 1 ppm (McGraw-Hill). Krauskopf (1979) reported the average abundance in shale was 1.5 ppm; however, there is probably only minimal shale in Hop Brook soils. Long and Morgan (1990) reported an ER-L of two, AET of 25, and an ER-M of 25 ppm with a moderate degree of confidence in the ER-L and ER-M. Kesler-Arnold and O'Hearn (1990) found background levels in Lower Michigan soils had a range from less than 0.025 to 23 ppm, with a mean of 5.9 ppm.

Antimony levels in Hop Brook Lake soils were too low to quantify, but were estimated at 3.1 to 68 ppm. The only other NED project with detectable levels of antimony found similar results; levels at Otter Brook Lake in New Hampshire were estimated at 13 to 67 ppm (NED, 1992). These levels appear to be within the expected range of unpolluted New England soils. The absence of detectable levels in Hop Brook's waters indicates antimony in soil is tied up in insoluble compounds. This is further evidence that antimony is not a concern at this project.

(3) Arsenic. Table 13 in Appendix B summarizes standards and data for arsenic.

Elemental arsenic is insoluble in water but many of its salts are highly soluble. In some parts of the western United States, arsenic compounds naturally occur (McKee & Wolf). Naturally occurring levels of arsenic in the earth's crustal soils have been variously reported as 1.81 (Aherns), two (EPA, 1977), and 6 ppm (Lisk, 1972). A survey of arsenic in Ontario soils where no arsenical insecticides were used reported means of 5.84 plus or minus 4.60 ppm in sandy soils, and 6.43 plus or minus 3.69 ppm in clay soils (Frank et al. 1976). Arsenic levels in dredged harbors in the Gulf of Maine (NED, 1980a) for 598 cases averaged 6.98 mg/Kg, and the mean plus two standard deviations was 22.3 mg/Kg. For 598 cases in dredged harbors from Cape Cod to western Connecticut, the mean arsenic level was 7.3 mg/Kg and the mean plus two standard deviations was 24.7 mg/Kg. An analysis of arsenic in the sediments from 6 lakes in Massachusetts found a mean of 14.1 mg/Kg and a range of 0.7 to 43 mg/Kg (Fratoni et al. 1972).



The Great Lakes Guidelines (EPA, 1977) define nonpolluted sediment as having less than 3 mg/Kg, moderately polluted as having 3-8 mg/Kg, and heavily polluted as having more than 8 mg/Kg of arsenic.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For arsenic, type I, II, III limits are <10, 10 - 20, and >20 ppm, respectively (Barr, 1987).

The State of Washington set sediment quality standards of 57 ppm arsenic and sediment cleanup standards of 93 ppm (Ginn and Pastorok, 1992).

The heavily polluted French River in Connecticut had a mean of 16.65 and a range of 2.1 to 31.4 ppm arsenic in its sediments (NED, 1979). Arsenic measurements in sediments from the highly polluted Ashtabula River in Ohio had a mean of 28.9 and a range of 12 to 56 mg/Kg (Leonard, 1986). Sediments from the polluted Oxoboxo River in Connecticut had a mean of 11 and a range of 8 to 16 mg/Kg arsenic (NED, 1980b), while the relatively unpolluted Oak Orchard Harbor, New York, sediments had arsenic levels varying from 2.1 to 5.7 with a mean of 3.2 mg/Kg (Smith et al. 1984). Unpolluted Winnepesaukee River sediments had 2.3 to 2.6 mg/Kg (Wood, 1984). It should be noted that pollution classifications of these waters are based on their overall conditions and not just the arsenic content of either water or sediments.

Median arsenic levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 3 mg/Kg in the heavily polluted Blackstone River, to 0.8 mg/Kg in the moderately polluted North River, to 4.2 mg/Kg in the lightly polluted Quinsigamond River, to 0.2 mg/Kg in the clean South River. Maximum arsenic levels in this study were 20, 4.4, 9.0, and 0.4 mg/Kg, respectively, from heavily polluted to clean. Sediments from Lake Quinsigamond, which was considered clean, had the highest level of arsenic recorded in this study--the median was 37 and the maximum was 94 mg/Kg. For many metals included in this survey, Lake Quinsigamond sediments had levels as high or higher than the heavily polluted ones of the Blackstone River. This is probably due to lake sediments being more likely to trap and retain arsenic. Fuller (1977) classified arsenic as only slowly mobile in soils. However, it should also be remembered that these rivers were classified as polluted, based on their general condition and not necessarily arsenic contents.

Long and Morgan (1990) reported an ER-L of 33, AET of 50, and an ER-M of 85 ppm with a low degree of confidence in the ER-L but moderate confidence in ER-M. Kesler-Arnold and O'Hearn (1990) found background levels in Lower Michigan soils had a range of 0.006 to 39 ppm, with a mean of 6.2 ppm.

Detectable levels of arsenic have been found in sediments at a number of other NED projects. At Thomaston Dam in Connecticut, 1.4 to 1.7 ppm were found in sediment samples from two stations (NED, 1992b). Arsenic measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results ranged from 0.9 to 2.5 with a mean of 1.9 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had 2.3 to 3.9 ppm (NED, 1988a), and Otter Brook Lake had 0.6 to 0.7 ppm (NED, 1992). The average of mean arsenic concentrations for all other NED projects was 1.8 ppm.

Arsenic levels in Hop Brook Lake soils ranged from 0.88 to 2.2 ppm. These levels are low and in the range of unpolluted soils. Lack of detectable concentrations in the waters of Hop Brook Lake is further evidence that arsenic is not a concern at this project.

(4) Barium. Table 14 in Appendix B summarizes standards and data for barium.

The average concentration of barium in the earth's crust is about 400 ppm (McGraw-Hill). Because its sulfate and carbonate salts are highly insoluble, barium is rarely found in natural waters. In 863 samples of the top 8 inches of United States soils, the geometric mean of barium was 430 ppm with a range from 10 to 1,500 ppm. Krauskopf reported the average abundance in shale was 600 ppm. Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range of less than 1.05 to 291 ppm, with a mean of 49 ppm.

The low toxicity of barium causes minimal concern about barium levels in water and sediments and, consequently, there is minimal data available on barium levels in sediments. The Great Lakes Guidelines (EPA, 1977) do not include barium. The highly polluted Ashtabula River in Ohio had 200 to 1,160 mg/Kg of barium in its sediments (Leonard, 1986).

Detectable levels of barium have been found in sediments at a number of other NED projects. At Thomaston Dam in Connecticut, 37 to 120 ppm were found in sediment samples from two stations (NED, 1992b). Barium measurements were

made on four sediment samples collected from Birch Hill Dam in Massachusetts; results ranged from 22.1 to 61.6 with a mean of 41.0 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had 59.8 to 68.0 ppm (NED, 1988a), and Otter Brook Lake had 36 to 110 ppm (NED, 1992). The average of mean barium concentrations for all other NED projects was 64 ppm.

With a range of 18 to 210 ppm, barium concentrations in Hop Brook sediments are well within the range of unpolluted conditions. The finding of only trace concentrations in Hop Brook Lake water is further evidence that barium is not a concern at this project.

(5) Beryllium. Table 15 in Appendix B summarizes standards and data for beryllium.

A relatively rare metal in the earth's crust (average concentration 50 ppm), beryllium is rarely found in surface waters because of insolubility of the carbonate and hydroxide salts (McKee and Wolf). There are no drinking water, aquatic life, or sediment criteria for beryllium. Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from less than 0.1 to 1.4 ppm, with a mean of 0.5 ppm.

Measurements of beryllium in sediments at other NED projects found levels too low to quantify. At Thomaston Dam in Connecticut, beryllium levels were estimated at 1.2 to 3.5 ppm (NED, 1992b). Levels were even lower at Otter Brook Lake in New Hampshire which had estimated levels of 0.43 to 1.2 ppm, compared to a detection limit in the blank of 0.5 ppm (NED, 1992). The overall estimated average of mean concentrations at these projects was 1.6 ppm.

In Hop Brook sediments, concentrations ranged from 0.17 to 1.8 ppm. These levels are within the expected range for background concentrations and typical of levels observed at other NED projects. In sum, beryllium levels are low and do not appear to be a cause for concern at this project.

(6) Cadmium. Table 16 in Appendix B summarizes standards and data for cadmium.

Biologically, cadmium is a nonessential, nonbeneficial element recognized to be of high toxic potential. It is deposited and accumulated in various body tissues and found in varying concentration throughout all areas where man lives. Within past decades industrial production and use of cadmium have increased with a concomitant increase in acute

cases of cadmiossis. Cadmium, by itself or in conjunction with other agents, may cause a variety of human ailments including tumors, kidney disorders, high blood pressure, arteriosclerosis, chronic diseases of old age, and cancer (EPA, 1976). Cadmium is used as a metallurgical alloy, in electroplating ceramics, pigmentation, and photography. Cadmium salts have been used as insecticides and antihelminthics (McKee and Wolf).

Naturally occurring levels of cadmium in the earth's crustal soils have been variously reported as 0.2 (Berry and Mason, 1959; Aherns, 1975), 0.3 (Bini et al. 1988), 0.06 to 0.50 (Ryan et al. 1980), and 0.01 to 0.70 mg/Kg (Baker and Chesnin, 1975). Barrett (1980) reported that most of the country has less than 0.2 ppm cadmium in soils and that few soils have greater than 1 ppm cadmium. Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from <0.025 to 4.1 ppm with a mean of 0.9 ppm. Miller and McFee (1983) examined surficial soil samples from five areas of industrialized northwestern Indiana; cadmium levels ranged from 17.6 in urban soils to 0.6 ppm in rural soils. At a depth of 30 to 36 centimeters, all soil samples had 0.1 to 0.2 ppm cadmium.

Cadmium levels for 597 cases in dredged harbors in the Gulf of Maine (NED, 1980a) averaged 3.12 mg/Kg, and the mean plus two standard deviations was 15.6 mg/Kg. For 601 cases for dredged harbors from Cape Cod to western Connecticut, the mean cadmium level was 5.9 mg/Kg and the mean plus two standard deviations was 26.9 mg/Kg. An analysis of cadmium in sediments from 16 lakes in Massachusetts found a mean of 2.6 mg/Kg and a maximum of 7.1 mg/Kg (Fratoni et al. 1982).

The Great Lakes Guidelines (EPA, 1977) define any sediment with greater than 6 mg/Kg of cadmium as polluted. No limits for moderately polluted or nonpolluted sediments were established.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For cadmium, type I, II, III limits are <5, 5 - 10, and >10 ppm, respectively (Barr, 1987).

The State of Washington set sediment quality standards of 5.1 ppm cadmium and sediment cleanup standards of 6.7 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an ER-L of 5, AET of five, and an ER-M of 9 ppm with a high degree of confidence in the ER-L and ER-M.

The heavily polluted French River in Connecticut had a mean of 7.35 and range of 0.7 to 25 ppm cadmium in its sediments (NED, 1979). Cadmium measurements in sediments from the highly polluted Ashtabula River in Ohio had a mean of 6.1 and range of 5 to 9 mg/Kg (Leonard, 1986). Polluted Oxoboxo River sediments in Connecticut had from less than 2 to 14 mg/Kg, with a mean of less than 9 mg/Kg cadmium (NED, 1980b), while the relatively unpolluted Oak Orchard Harbor, New York, sediments had cadmium levels varying from 0.6 to 2.4, with a mean of 2.1 mg/Kg (Smith et al. 1984). It should be noted that pollutional classifications of these waters are based on their overall condition and not just cadmium content of either the water or sediments.

Median cadmium levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 17 mg/Kg in the heavily polluted Blackstone River, to 0.9 mg/Kg in the moderately polluted North River, to 0.3 mg/Kg in the lightly polluted Quinsigamond River, to 0.2 mg/Kg in the clean South River. Maximum cadmium levels in this study followed the same neat progression from 150 mg/Kg to 5.5, 0.6, and 0.3 mg/Kg, respectively, from heavily polluted to clean. Lake Quinsigamond, which was considered clean, had sediments with a median of 2.9 mg/Kg and maximum of 5.5 mg/Kg of cadmium. That clean Lake Quinsigamond had sediments with cadmium levels in the range of moderately polluted to heavily polluted river sediments is not too surprising since lake sediments seem more likely to trap and retain metals. Fuller (1977) classified cadmium as only slowly mobile in soils due to its tendency to form insoluble precipitates in oxidizing conditions. Also, it should be remembered that these rivers were classified as polluted, based on their general conditions and not necessarily cadmium contents.

Detectable levels of cadmium have been found in sediments at a number of other NED projects, but were generally too low to quantify. At Thomaston Dam, estimated levels of 1.2 to 3.6 ppm were found in sediment samples from two stations (NED, 1992b). Cadmium measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results gave estimated levels of 0.4 to 1.0 ppm, with a mean of 0.6 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had estimated levels of 2 to 3 ppm (NED, 1988a), and Otter Brook Lake had estimated levels of 0.43 to 1.2 ppm (NED, 1992). The average mean

cadmium concentrations for all other NED projects was 1.3 ppm.

In Hop Brook sediments, concentrations ranged from less than detectable (0.5 ppm) at station HB05 to 3.4 ppm at station HB14. Because it is a trap for fine-grained sediments, station HB14 would be expected to have highest levels of cadmium. The level at station HB14 was below the ER-L, ER-M, and AET; met Washington State and Massachusetts DEQE standards for unpolluted sediments; and was within the range observed in background concentrations and other NED projects. Sediment cadmium concentrations are not a concern at this project.

(7) Calcium. The importance of calcium in soils is that it increases hardness of water coming in contact with the soil. As hardness reduces toxicity of metal ions in water to aquatic life, increased calcium is generally a good thing in New England. Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from 240 to 177,000 ppm, with a mean of 50,200 ppm. Other NED projects, where calcium has been measured in soils, include Thomaston Dam in Connecticut, with a range of 1,900 to 4,100 ppm (NED, 1992b), and Otter Brook Lake in New Hampshire, with a range of 440 to 730 ppm (NED, 1992). With a range of 1,500 to 3,200 ppm, calcium levels in Hop Brook soils are typical of New England's granitic soils.

(8) Chromium. Table 17 in Appendix B summarizes standards and data for chromium.

Although chromium has oxidation states ranging from  $\text{Cr}^{-2}$  to  $\text{Cr}^{+6}$ , the trivalent form is found most commonly in nature, and the hexavalent form is the most toxic. Chromium is found in air, soil, some foods, and most biological systems, and is recognized as an essential trace element for humans (EPA, 1976). Hexavalent chromium salts are used extensively in metal pickling and plating operations, anodizing aluminum, in the leather industry as a tanning agent, in the manufacture of paints, dyes, explosives, ceramics, paper, and many other substances. Trivalent chromium salts, on the other hand, are used much less extensively, being employed as mordants in textile dyeing, ceramic and glass industries, and in photography. Chromium compounds are also used as corrosion inhibitors in cooling waters (McKee and Wolf).

Chromium is the 17th most abundant nongaseous element in the earth's crust (EPA, 1976). Natural occurring levels of chromium in the earth's crustal soils have been variously reported as 80 (EPA, 1976), 100 (Aherns, 1975), 200 (Berry

and Mason, 1959), and 5 to 3000 mg/Kg (Allaway, 1968). Schacklette (1971) found that American soils may contain 1 to 1,500 ppm. Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range of 0.56 to 58 ppm with a mean of 11.8 ppm. Krauskopf (1979) found the average abundance of chromium in shale was 100 ppm. Chromium levels for 597 cases in dredged harbors in the Gulf of Maine (NED, 1980a) averaged 112 mg/Kg, and the mean plus two standard deviations was 563 mg/Kg. For 598 cases for dredged harbors from Cape Cod to western Connecticut, the mean chromium level was 160 mg/Kg and the mean plus two standard deviations was 783 mg/Kg. An analysis of chromium in the sediments from 16 lakes in Massachusetts found a mean of 36 mg/Kg and a range of 5 to 150 mg/Kg (Fratoni et al. 1982).

The Great Lakes Guidelines (EPA, 1977) define nonpolluted sediment as having less than 25 mg/Kg, moderately polluted having 25 to 75 mg/Kg, and heavily polluted having more than 75 mg/Kg of chromium.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For chromium, type I, II, III limits are <100, 100 - 300, and >300 ppm, respectively (Barr, 1987).

The State of Washington set sediment quality standards of 260 ppm chromium and sediment cleanup standards of 270 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an AET of 260 to 370 ppm, an ER-L of 80, and an ER-M of 145 ppm, with a moderate degree of confidence in the ER-L and ER-M.

Heavily polluted sediments from impoundments in the French River in Connecticut had a mean of 1,370 and a range of 23 to 4710 ppm chromium (NED, 1979). The highly polluted Ashtabula River in Ohio had 64 to 629 mg/Kg, with a mean of 312 mg/Kg of chromium in its sediments (Leonard, 1986). Polluted Oxoboxo River sediments in Connecticut had 34 to 83 mg/Kg, with a mean of 61.6 mg/Kg chromium (NED, 1980b), while the relatively unpolluted Oak Orchard Harbor, New York, sediments had a mean chromium level of 1.2 mg/Kg and a range of 6.4 to 9.5 mg/Kg (Smith et al. 1984). Clean Winnepesaukee River sediments had 12 to 13 mg/Kg chromium (Wood, 1984). It should be noted that pollutional classifications of these bodies of water and sediments were based on their overall

conditions and not just the chromium content of either the water or sediments.

Median chromium levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 130 mg/Kg in the heavily polluted Blackstone River, to 9.8 mg/Kg in the moderately polluted North River, to 16 mg/Kg in the lightly polluted Quinsigamond River, to 6.2 mg/Kg in the clean South River. Maximum chromium levels in this study were 900, 363, 40, and 7.5 mg/Kg, respectively, from heavily polluted to clean. Lake Quinsigamond, which was considered clean, had sediments with a median of 34 mg/Kg and a maximum of 73 mg/Kg of chromium. That clean Lake Quinsigamond had sediments with chromium levels in the range of slightly polluted to heavily polluted river sediments is not surprising since lake sediments seem more likely to trap and retain metals. Also, it should be remembered that these rivers were classified as polluted based on their general condition and not necessarily chromium contents. Fuller (1977) classified chromium as only slowly mobile in soils due to its tendency to form insoluble precipitates in oxidizing conditions.

Detectable levels of chromium have been found in sediments at a number of other NED projects. At Thomaston Dam in Connecticut, levels of 26 to 52 ppm with a mean of 39 ppm were found in sediment samples from two stations (NED, 1992b). Chromium measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results gave levels of 4.4 to 24.9, with a mean of 10.3 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had levels of 22 to 32, with a mean of 27 ppm (NED, 1988a), and Otter Brook Lake had levels of 16 to 40, with a mean of 28 ppm (NED, 1992). The average of the mean chromium concentrations for all other NED projects was 26.1 ppm.

With a range of 4.6 to 48 and a mean of 26.3 ppm, chromium levels at Hop Brook Lake meet Washington State and Massachusetts DEQE standards for unpolluted sediments, and are below the ER-L and ER-M, are within the range observed at other NED projects, and within the range reported for background concentrations in Michigan soils. However, the 48 ppm measured at station HB14 falls into the moderately polluted range for the Great Lakes Sediment Guidelines. Station HB14 is a natural trap for fine-grained sediments and shows uniformly higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Chromium levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of



detectable levels of chromium in waters of Hop Brook Lake is a further indication that chromium is not a concern at this project.

(9) Cobalt. Table 18 in Appendix B summarizes standards and data for cobalt.

Cobalt has a relatively low toxicity to man, and traces are essential to nutrition (McKee & Wolf). Average concentration of cobalt in igneous rocks is 0.001 percent equal to 10 ppm (McGraw-Hill). Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from less than 1.25 to 18 ppm, with a mean of 5.8 ppm. The USGS reported a maximum of 2 ppm cobalt in Merrimack River sediments near Nashua, New Hampshire (USGS, 1975). Levels measured in sediments at other NED projects were too low to quantify, but were estimated at 8.7 to 12 ppm at Thomaston Dam in Connecticut (NED, 1992b), and 4.5 to 17 ppm at Otter Brook Lake in New Hampshire (NED, 1992).

Cobalt levels in Hop Brook sediments were too low to quantify but were estimated at 3 to 20 and a mean of 11.5 ppm. These levels are somewhat high compared to Merrimack River sediments, but are within the background range found in Michigan soils and similar to levels found at other NED projects. The trace levels found in the water and low toxicity of cobalt indicate it is not a concern at Hop Brook Lake.

(10) Copper. Table 19 in Appendix B summarizes standards and data for copper.

Copper salts occur in natural surface waters only in trace amounts, up to approximately 0.05 mg/l. Consequently, their presence is generally the result of pollution attributable to corrosive action of water on copper and brass tubing, industrial effluents, or frequently use the copper compounds for control of undesirable plankton organisms (McKee and Wolf). Copper is an essential trace element for the propagation of plants and is required in animal metabolism (EPA, 1986).

Uses for copper include electrical products, coins, and metal plating. Copper frequently is alloyed with other metals to form various brasses and bronzes. Oxides and sulfates of copper are used for pesticides, algicides, and fungicides. Copper frequently is incorporated into paints and wood preservatives to inhibit growth of algae and invertebrate organisms (EPA, 1986).

Naturally occurring levels of copper in the earth's crustal soils have been variously reported as 45 (Berry and Mason, 1959), 55 (Aherns, 1975), and 2 to 100 mg/Kg (Allaway, 1968). Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from less than 0.1 to 74 ppm, with a mean of 12.6 ppm. A survey of Ontario agricultural soils found a mean of 65 ppm in organic soils, 20 ppm in sandy soils, and 25.4 ppm overall (Frank et al. 1976). Miller and McFee (1983) examined surficial soil samples from five areas of industrialized northwestern Indiana; copper levels ranged from 212 in urban soils to 75 ppm in rural soils. At a depth of 30 to 36 centimeters, all soil samples had 1.5 to 3.7 ppm copper.

Copper levels for 591 cases in dredged harbors in the Gulf of Maine averaged 83 mg/Kg (NED, 1980a), and the mean plus two standard deviations were 342 mg/Kg. For 601 cases for dredged harbors from Cape Cod to western Connecticut, the mean copper level was 260 mg/Kg and the mean plus two standard deviations was 1,330 mg/Kg. An analysis of copper in sediments from 16 lakes in Massachusetts found a mean of 284 mg/Kg and a range of 20 to 940 mg/Kg (Fratoni et al. 1982).

A study of precipitated copper in lake bottom muds, resulting from copper sulfate application to control nuisance algae, concluded that the toxic limit to a midge and finger-nail clam was about 9,000 mg/Kg of copper in mud on a dry weight basis (EPA, 1976).

The Great Lakes Guidelines (EPA, 1977) define nonpolluted sediment as having less than 25 mg/Kg, moderately polluted having 25 to 50 mg/Kg, and heavily polluted having more than 50 mg/Kg of copper.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For copper, type I, II, III limits are <200, 200 - 400, and >400 ppm, respectively (Barr, 1987).

The State of Washington set sediment quality standards of 390 ppm chromium and sediment cleanup standards of 390 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an ER-L of 70, AET of 300, and an ER-M of 390 ppm, with a high degree of confidence in the ER-L and ER-M.

Heavily polluted sediments from the French River in Connecticut had a mean copper concentration of 541 ppm and range of 5 to 1,790 ppm (NED, 1979). The highly polluted Ashtabula River in Ohio had a mean of 48.7 mg/Kg and a range of 34 to 69 mg/Kg of copper in its sediments (Leonard, 1986). Polluted Oxoboxo River sediments in Connecticut had 170 to 350, with a mean of 275 mg/Kg copper (NED, 1980b), while the relatively unpolluted Oak Orchard Harbor, New York, sediments had copper levels varying from 13 to 80, with a mean of 23 mg/Kg (Smith et al. 1984). Unpolluted Winnepesaukee River sediments had 13 to 15 mg/Kg of copper (Wood, 1984). It should be noted that when describing these rivers as "polluted" or "nonpolluted," reference is made to the overall condition of the river and not necessarily the heavy metal content of its sediments or even the river water.

Median copper levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 320 mg/Kg in the heavily polluted Blackstone River, to 15 mg/Kg in the moderately polluted North River, to 13 mg/Kg in the lightly polluted Quinsigamond River, to 6.0 mg/Kg in the clean South River. Maximum copper levels in this study followed the same neat progression from 1850 mg/Kg to 635, 21, and 8.4 mg/Kg, respectively, from heavily polluted to clean. Lake Quinsigamond, which was considered clean, had sediments with a median of 94 mg/Kg and a maximum of 180 mg/Kg of copper. That clean Lake Quinsigamond had sediments with copper levels in the range of moderately polluted to heavily polluted river sediments is not surprising as lake sediments seem more likely to trap and retain metals. Also, it should be remembered that these rivers were classified as polluted based on their general condition and not necessarily their copper contents. Fuller (1977) classified copper as moderately mobile in soils, as he found it was absorbed more strongly by soil than other moderately mobile metals such as iron, lead, and zinc, but its complexes were less stable.

Detectable levels of copper have been found in sediments at a number of other NED projects. At Thomaston Dam in Connecticut, levels of 51 to 110 ppm, with a mean of 80 ppm were found in sediment samples from two stations (NED, 1992b). Copper measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results gave levels of 6.4 to 40.5, with a mean of 24.5 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had levels of 25 to 25.5, with a mean of 25.25 ppm (NED, 1988a), and Otter Brook Lake had levels of 3.6 to 13, with a mean of 8.4 ppm (NED, 1992). The average of mean copper concentrations for all other NED projects was 35 ppm.

With a range of 13 to 39 and a mean of 26 ppm, copper levels at Hop Brook Lake meet the Washington State, Massachusetts DEQE, and Great Lakes Sediment Guidelines for unpolluted sediments; are below the ER-L, ER-M, and AET; are within the range found at other NED projects; and within the range of naturally occurring unpolluted soils. The absence of detectable levels of copper in the waters of Hop Brook Lake is further indication that copper is not a concern at this project.

(11) Iron. Table 20 in Appendix B summarizes standards and data for iron.

Iron is one of the most common elements in the earth's crust, with an average concentration of about 5 percent (50,000 ppm). Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from 880 to 48,000 ppm, with a mean of 11,800 ppm. Levels measured in sediments at other NED projects included 10,000 to 20,000 ppm at Thomaston Dam in Connecticut (NED, 1992b), and 12,000 to 28,000 ppm at Otter Brook Lake in New Hampshire (NED, 1992).

The finding of 9,800 to 44,000 ppm at Hop Brook Lake does not indicate a valuable iron deposit, but neither does it indicate an unusual condition. Iron at station HB14 is higher than that found at the two other NED projects with available data, but is within the range of naturally occurring conditions. The elevated iron in sediments at this station might be important because of the role of iron in phosphorus recycling; however, sediment iron levels are not a problem at this project.

(12) Lead. Table 21 in Appendix B summarizes standards and data for lead.

Lead has no beneficial or desirable nutritional effects as it is a toxic metal that tends to accumulate in tissues of man and animals. In addition to their natural occurrence, lead and its compounds may enter and contaminate the environment through mining, smelting, processing, and usage, especially through automobile exhausts. Lead enters the aquatic environment through precipitation, lead dust fallout, erosion and leaching of soil, municipal and industrial waste discharges, and runoff of fallout deposits from streets and other surfaces (EPA, 1976).

Certain lead salts, such as acetate and chloride, are readily soluble, but owing to the fact that carbonate and hydroxide are insoluble and sulfate is only sparingly soluble, lead will not remain long in natural waters (McKee and Wolf).

Naturally occurring levels of lead in the earth's crustal soils have been variously reported as 12.5 (Aherns, 1975), 16 (Lisk, 1980), a mean of 10 with a range of 2 to 200 mg/Kg (Allaway, 1968), and a mean of 15 with a range of 1 to 200 mg/Kg (Swaine, 1955). A study of the total lead content of soils in this country found an average of 16 ppm and a range of 10 to 700 ppm (Lisk, 1980). Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from less than 0.5 to 140 ppm, with a mean of 10.3 ppm. Krauskopf reported the average abundance of lead in shale was 20 ppm. Miller and McFee (1983) examined surficial soil samples from five areas of industrialized northwestern Indiana; lead levels ranged from 755 in urban soils to 163 ppm in rural soils. At a depth of 30 to 36 centimeters, all soil samples had 0.2 to 0.9 ppm lead. Friedland, et al. (1992) examined lead in forest floor samples from New England and New York, and found a mean level of 146 ppm in 1980 and 121 ppm in 1990.

Lead levels for 598 cases in dredged harbors in the Gulf of Maine (NED, 1980a) averaged 83 mg/Kg, and the mean plus two standard deviations was 285 mg/Kg. For 601 cases for dredged harbors from Cape Cod to western Connecticut, the mean lead level was 145 mg/Kg and the mean plus two standard deviations was 711 mg/Kg. An analysis of lead in sediments from 16 lakes in Massachusetts found a mean of 274 mg/Kg and a range of 72 to 970 mg/Kg (Fratoni et al. 1982).

The Great Lakes Guidelines (EPA, 1977) define nonpolluted sediment as having less than 90 mg/Kg, moderately polluted having 90 to 200 mg/Kg, and heavily polluted having more than 200 mg/Kg of lead.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For lead, type I, II, III limits are <100, 100 - 200, and >200 ppm, respectively (Barr, 1987).

The State of Washington set sediment quality standards of 450 ppm lead and sediment cleanup standards of 530 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an ER-L of 35, AET of 300, and an ER-M of 110 ppm, with a moderate degree of confidence in the ER-L and a high degree in the ER-M.

Heavily polluted sediments from the French River in Connecticut had a mean of 358 mg/Kg of lead and a range of 13 to 840 mg/Kg (NED, 1979). The highly polluted Ashtabula River in Ohio had 38 to 89, with a mean of 63.5 mg/Kg of lead in its sediments (Leonard, 1986). Polluted Oxoboxo River sediments in Connecticut had 12 to 340 with a mean of 187 mg/Kg lead (NED, 1980b), while the relatively unpolluted Oak Orchard Harbor, New York, sediments had lead levels varying from 6.4 to 34, with a mean of 13.9 mg/Kg (Smith et al. 1984). Unpolluted Winnepesaukee River sediments had 88 to 93 mg/Kg (Wood, 1984). It should be noted that when describing these rivers as "polluted" or "nonpolluted," reference is made to the overall condition of the river and not necessarily the heavy metal content of its sediments or even the river water.

Median lead levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 200 mg/Kg in the heavily polluted Blackstone River, to 50 mg/Kg in the moderately polluted North River, to 45 mg/Kg in the lightly polluted Quinsigamond River, to 18 mg/Kg in the clean South River. Maximum lead levels in this study followed the same neat progression from 980 mg/Kg to 300, 120, and 50 mg/Kg, respectively, from heavily polluted to clean. Lake Quinsigamond, which was considered clean, had sediments with a median of 265 mg/Kg and a maximum of 400 mg/Kg of lead. That clean Lake Quinsigamond had sediments with lead levels in the range of heavily polluted river sediments is not surprising, as lake sediments seem more likely to trap and retain metals. Also, it should be remembered that these rivers were classified as polluted, based on their general condition and not necessarily their lead contents. Fuller classified lead as moderately mobile in soils; he found it was absorbed more strongly by soil than other moderately mobile metals such as iron and zinc, but its complexes were less stable.

Detectable levels of lead have been found in sediments at a number of other NED projects. At Thomaston Dam in Connecticut, levels of 37 to 86 ppm with a mean of 62 ppm were found in sediment samples from two stations (NED, 1992b). Lead measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results gave levels of 22.1 to 78.6, with a mean of 46.3 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had levels of 65.8 to 73.4, with a mean of 69.6 ppm (NED, 1988a), and Otter Brook Lake had levels of 8.2 to 16, with a mean of 8.1 ppm (NED, 1992). The average of mean concentrations for all other NED projects was 46.5 ppm.

With a range of 16 to 58 and a mean of 37 ppm, lead levels at Hop Brook Lake meet the Washington State and Massachusetts DEQE standards for unpolluted sediments. These levels are also below the ER-M and AET; however, the 58 ppm level at station HB14 exceeds the ER-L of 35 ppm and places the sample in the moderately polluted category of the Great Lakes Sediment Guidelines. On the other hand, even the highest level at Hop Brook is within the range found at most other NED projects, well below the mean found in northeast forest floors, within the range found of background levels in Michigan soils, and within the range found in sediments in unpolluted rivers. The absence of detectable levels of lead in waters of Hop Brook Lake is a further indication that lead levels in sediments are not a concern at this project.

(13) Manganese. Table 22 in Appendix B summarizes standards and data for manganese.

This metal is not found pure in nature but its ores are very common and widely distributed. The average concentration in igneous rocks is about 1,000 ppm (Considine, 1976). Its oxides, carbonates, and hydroxides are only sparingly soluble. Consequently, it is rarely found in surface waters above 1 ppm, but under reducing conditions it can reach high concentrations in groundwater. Manganese frequently accompanies iron in groundwater (McKee and Wolf). Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from 11 to 4,000 ppm, with a mean of 319 ppm. In 1975, the USGS reported manganese levels in sediments of 45 to 47 ppm from the Merrimack River at Nashua, New Hampshire. Other NED projects where manganese has been measured in sediments include Otter Brook Lake in New Hampshire where 51 to 100 ppm were found (NED, 1992), and Thomaston Dam in Connecticut where 75 to 570 ppm were measured (NED, 1992b).

With a range of 95 to 810 ppm, manganese levels in sediments at Hop Brook are within the range of naturally occurring conditions. The 810 ppm found at station HB14, like the 44,000 ppm iron at that station, is higher than levels found in sediments at other NED projects; however, this is not surprising because the chemistry of iron and manganese in natural waters is very similar. Manganese levels in sediments at Hop Brook Lake are not a problem.

(14) Magnesium. As one of the most common elements in the earth's crust, amounting to 2.1 percent (21,000 ppm), the ores of magnesium are among the most widely distributed. Like calcium, magnesium is important because it contributes to the hardness of water. Kesler-Arnold and O'Hearn (1990)

found background levels in lower Michigan soils had a range from 102 to 66,900 ppm, with a mean of 15,500 ppm. Other NED projects where magnesium has been measured in sediments include Otter Brook Lake in New Hampshire where 3,000 to 7,800 ppm were found (NED, 1992), and Thomaston Dam in Connecticut where 2,400 to 4,500 ppm were measured (NED, 1992b).

With a range of 1,700 to 8,700, magnesium levels in sediments at Hop Brook Lake are within naturally occurring conditions.

(15) Mercury. Table 23 in Appendix B summarizes standards and data for mercury.

Biologically, mercury is a nonessential, nonbeneficial element recognized to be of high toxic potential. It is widely distributed in the environment and found in rocks of all classes although it chiefly occurs as cinnabar, HgS. Synthetic organic and inorganic salts of mercury are used commercially and industrially as medicinal products, disinfectants, detonators, pigments, and for photoengraving. Many mercury salts are highly soluble in water (McKee and Wolf). Mercury is naturally released to the environment from volcanos and hot springs (Miller and Buchanan, 1979). An estimated 20,000 tons of mercury enter the environment annually through anthropogenic activities including industrial discharges, metal smelters, and coal combustion (Friberg et al. 1986).

Mercury released to aquatic systems appears to bind to dissolved matter or fine particulates (National Research Council Canada, 1979, and World Health Organization, 1976). Mercury bioaccumulates and concentrates in the food chain (Environment Canada, 1982). Sittig (1980) reported bioconcentration factors of 63,000 for freshwater fish and 10,000 for saltwater fish.

Naturally occurring levels of mercury in the earth's crustal soils have been variously reported as 0.8 ppm (Jonasson, 1970), 0.1 ppm (Huginin, 1975, and Vinogradov, 1959), 0.03 to 0.3 ppm (Hawkes and Webb, 1962), 0.3 ppm (Lisk, 1972), and 0.5 ppm (Fuller, 1977). Schacklette et al. (1971), examined 912 soil samples from the United States and reported that the range for the entire U.S.A. was 0.010 to 4.6 ppm, with an arithmetic mean of 0.112 ppm. For western U.S.A. soils, the range was 0.010 to 4.6 ppm, with a mean of 0.083 ppm; for eastern U.S.A. soils, the range was 0.010 to 3.4 ppm, with a mean of 0.147 ppm. Kesler-Arnold and O'Hearn (1990) examined background levels in lower Michigan soils, and found sandy soils had a range from <0.005 to 0.13, with



a mean of 0.04 ppm; silty soils had a range from <0.029 to 0.10, with a mean of 0.05 ppm; and clayey soils had a range of 0.009 to 0.70, with a mean of 0.06 ppm. Mercury levels for 597 cases in dredged harbors in the Gulf of Maine (NED, 1980a) averaged 0.573 ppm, and the mean plus two standard deviations was 3 ppm. For 602 cases for dredged harbors from Cape Cod to western Connecticut, the mean mercury level was 0.795 ppm, and the mean plus two standard deviations was 3.2 ppm. An analysis of mercury in sediments from 16 lakes in Massachusetts found a mean of 0.23 and a range of 0.12 to 0.40 ppm (Fratoni et al. 1982).

The Great Lakes Guidelines (EPA, 1977) define any sediment with greater than 1 ppm of mercury as polluted. No limits for moderately polluted or nonpolluted sediments were established.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For mercury, sediment concentrations must be less than 10 ppm to meet type I and II limits (Barr, 1987).

The State of Washington set sediment quality standards of 0.41 ppm, and mercury and sediment cleanup standards of 0.59 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an ER-L of 0.15, an ER-M of 1.3, and an AET of 1 ppm, with a moderate degree of confidence in the ER-L and a high degree of confidence in the ER-M. Based on equilibrium partitioning, they estimated that sediments with 4 percent total organic carbon would meet acute marine water quality criteria if mercury content of the sediments did not exceed 0.6 ppm, and chronic criteria, if sediment mercury levels did not exceed 0.03 ppm.

Mercury measurements in sediments from the highly polluted Ashtabula River in Ohio had a mean of 2.15 and a range of 0.78 to 4.7 ppm (Leonard, 1986), and highly polluted Blackstone River sediments in Massachusetts had a median of 1.8 and a maximum of 6.4 ppm (Isaac and Delaney, 1975). Polluted Oxoboxo River sediments in Connecticut had 0.09 to 1.3 ppm, with a mean of 0.39 ppm mercury (NED, 1980b). Isaac and Delaney (1975) measured mercury levels in polluted Massachusetts river sediments; they found the North River had a median of 0.33 and maximum of 5.5 ppm, and Quinsigamond

River had a median of 0.24 and maximum of 0.34 ppm mercury. Relatively unpolluted Oak Orchard Harbor, New York, sediments had mercury levels varying from less than 0.1 to 0.2 with a mean of 0.1 ppm (Smith et al. 1984). Measurements by Isaac and Delaney (1975) of mercury levels in unpolluted Massachusetts sediments found a median of 0.04 and a maximum of 0.07 ppm in the South River, and a median of 0.46 and maximum of 7 ppm in Lake Quinsigamond. That clean Lake Quinsigamond had sediments with mercury levels in the range of moderately polluted to heavily polluted river sediments is not too surprising, as lake sediments seem more likely to trap and retain metals. Finally, a study of unpolluted Winnepesaukee River sediments in New Hampshire found 0.10 to 0.12 ppm (Wood 1984). It should be noted that the pollutional classifications of these waters are based on their overall condition and not just mercury content of either the water or sediments.

Detectable levels of mercury have been found in sediments at a number of other NED projects, but were often too low to quantify. At Thomaston Dam in Connecticut, levels of 0.03 to 0.14 ppm were found in sediment samples from two stations (NED, 1992b). Mercury measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results varied from less than 0.04 to 0.36, with a mean of 0.13 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had levels of 0.25 to 0.52 ppm (NED, 1988a), and Otter Brook Lake had less than 0.03 ppm at both stations (NED, 1992). The average of mean mercury concentrations for all other NED projects was 0.15 ppm.

In Hop Brook sediments, concentrations ranged from less than detectable (0.03 ppm) at station HB05 to 0.12 ppm at station HB14. Because it is a trap for fine-grained sediments, station HB14 would be expected to have highest levels of mercury. Levels in Hop Brook Lake sediments were below the ER-L, ER-M, and AET; met Washington State, Great Lakes, and Massachusetts DEQE sediment classification standards for unpolluted sediments, and were well within the range observed for background concentrations and at other NED projects. Sediment mercury concentrations are not a concern at this project.

(16) Nickel. Table 24 in Appendix B summarizes standards and data for nickel.

Nickel is considered relatively nontoxic to man, and a limit for nickel is not included in the EPA National Primary Drinking Water Regulations. Studies of the toxicity of

nickel to aquatic life indicate that tolerances vary widely and are influenced by species, pH, synergistic effects, and other factors (EPA, 1976).

Nickel compounds are found in many ores and minerals. As a pure metal it is not a problem in water pollution because it is not affected by, or soluble in, water. However, many nickel salts are highly soluble in water and, since they are used in metal-plating works, they may be discharged to ground or surface waters (McKee and Wolf).

Naturally occurring levels of nickel in the earth's crustal soils have been variously reported as 40 (Lisk, 1980), 75 (Aherns, 1975), and 80 mg/Kg (Berry and Mason, 1959); a mean of 10 with a range of 2 to 200 mg/Kg (Allaway, 1968); and a mean of 15 with a range of 1 to 200 mg/Kg (Swaine, 1955). A study of the total nickel content of soils in this country found an average of 20 ppm and a range of 45 to 70 ppm (Isaac and Delaney, 1975). Kesler-Arnold and O'Hearn (1990) found background levels in Lower Michigan soils had a range from less than 0.25 to 53 ppm, with a mean of 14.2 ppm.

Nickel levels for 598 cases in dredged harbors in the Gulf of Maine (NED, 1980a) averaged 36 mg/Kg, and the mean plus two standard deviations was 92 mg/Kg. For 600 cases for dredged harbors from Cape Cod to western Connecticut, the mean nickel level was 49 mg/Kg and the mean plus two standard deviations was 139 mg/Kg. An analysis of nickel in sediments from 16 lakes in Massachusetts found a mean of 56 mg/Kg and a range of 20 to 201 mg/Kg (Fratoni, 1975).

The Great Lakes Guidelines (EPA, 1977) define unpolluted sediment as having less than 20 mg/Kg, moderately polluted having 20 to 50 mg/Kg, and heavily polluted having more than 50 mg/Kg of nickel.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For nickel, type I, II, III limits are <50 , 50 - 100 and >100 ppm, respectively (Barr, 1987).

Long and Morgan (1990) reported an AET of 28 to 170, an ER-L of 30, and an ER-M of 50 ppm, with a moderate degree of confidence in the ER-L and ER-M.

Heavily polluted sediments from the French River in Connecticut had a mean nickel concentration of 28.5 and a range of 9.9 to 50.9 ppm (NED, 1979). Highly polluted Ashtabula River in Ohio had 28 to 63, with a mean of 44.1 mg/Kg of nickel in its sediments (Leonard, 1986). Polluted Oxoboxo River sediments in Connecticut had 20 to 40, with a mean of 30 mg/Kg nickel (NED, 1980b), while the relatively unpolluted Oak Orchard Harbor, New York, sediments had nickel levels varying from 14 to 20, with a mean of 18 mg/Kg (Smith et al. 1984). Unpolluted Winnepesaukee River sediments had less than detectable levels of nickel (Wood, 1984). When describing these rivers as "polluted" or "nonpolluted," reference is made to the overall condition of the river and not necessarily the heavy metal content of its sediments or even the river water.

Median nickel levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 68 mg/Kg in the heavily polluted Blackstone River, to 8.1 mg/Kg in the moderately polluted North River, to 16 mg/Kg in the lightly polluted Quinsigamond River, to 3.6 mg/Kg in the clean South River. Maximum nickel levels in this study ranged from 320 to 32, 64, and 4.2 mg/Kg, respectively, from heavily polluted to clean. Lake Quinsigamond, which was considered clean, had sediments with a median of 46 mg/Kg and a maximum of 48 mg/Kg of nickel. It should be remembered that these rivers were classified as polluted, based on their general condition and not necessarily their heavy metal contents.

Detectable levels of nickel have been found in sediments at a number of other NED projects; however these levels were often below the practical quantification limit. At Thomaston Dam in Connecticut, estimated levels of 31 to 38 ppm with a mean of 34 ppm were found in sediment samples from two stations (NED, 1992b). Nickel measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results gave levels of 5 to 12.3, with a mean of 9 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had levels of 11 to 15, with a mean of 13 ppm (NED, 1988a), and Otter Brook Lake had estimated levels of 7.2 to 26, with a mean of 17 ppm (NED, 1992). The average of mean concentrations for all other NED projects was 18 ppm.

In Hop Brook sediments, nickel concentrations were too low to quantify and were estimated at 5.1 to 31, with a mean of 18 ppm. These levels meet Massachusetts DEQE standards for unpolluted sediments, are below the ER-M, essentially meet the ER-L, and are within the range measured at

other NED projects. However, the estimated 31 ppm at station HB14 is in the range of moderately polluted sediments according to the Great Lakes Sediment Guidelines. Station HB14 is a natural trap for fine-grained sediments to which nickel is likely to attach itself. On the whole, nickel levels in sediments at Hop Brook Lake are typical of naturally occurring conditions and not a cause for concern. The absence of detectable levels of nickel in the waters of Hop Brook Lake is a further indication that nickel is not a concern at this project.

(17) Potassium. Potassium is an essential nutritional element for humans. One of the more common elements, potassium constitutes 2.4 percent (24,000 ppm) of the earth's crust (McKee and Wolf). Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from less than 122 to 4,450 ppm, with a mean of 1,660 ppm. Other NED projects where potassium levels in sediments have been measured include Thomaston Dam in Connecticut which had 1,200 to 2,300 ppm (NED, 1992b), and Otter Brook Lake in New Hampshire which had 1,900 to 9,800 ppm (NED, 1992).

With a range of 750 to 6,100 ppm, potassium levels in Hop Brook soils are within the range of naturally occurring conditions.

(18) Silver. Table 25 in Appendix B summarizes standards and data for silver.

In nature, silver is found in the elemental form and combined in various ores. From these ores, silver ions may be leached into ground and surface waters, but since many silver salts such as chloride and sulfide are insoluble, silver ions cannot be expected to occur in significant concentrations in natural waters (McKee and Wolf).

Silver is used in jewelry and silverware, alloys, for electroplating, food processing, photography, ink manufacture, and as an antiseptic (McKee and Wolf). Silver is also released to the environment through industrial discharges, smelting operations, coal combustion, and incineration of urban refuse (Freeman, 1979).

Biologically, silver is a nonessential, nonbeneficial element recognized as causing localized skin discoloration in humans, and as being systemically toxic to aquatic life. Because of its strong bactericidal action, silver has been considered for use as a water disinfectant (EPA, 1976).

Sorption and precipitation processes are effective in

reducing concentrations of dissolved silver in aquatic systems, which lead to higher concentrations in bed sediments than in overlying waters. Sorption by manganese dioxide and precipitation with halides are probably the dominant controls on the mobility of silver in the aquatic environment (Callahan, et al. 1979).

Although algae, daphnia, freshwater mussels, and fat-head minnow are all capable of accumulating silver, the food chain is not an important route of silver accumulation for animals at higher trophic levels, suggesting no food chain magnification (Luoma and Jenne, 1977).

Naturally occurring level of silver in the earth's crustal soils is reported as 0.1 ppm by Windholz, et al. (1976). Lindsay (1979) gives the average silver content of soils as 0.05 ppm and the common range is 0.01 to 5 ppm. Kesler-Arnold (1990) reported background concentrations of silver in Michigan soils as ranging from less than 0.03 to 4.2, with an overall mean of 1.1 ppm. Friberg (1986) reported finding 14 to 20 ppm silver in sediments in Californian coastal basins.

The State of Washington set sediment quality standards of 6.1 ppm silver and sediment cleanup standards of 6.1 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an ER-L of one, an ER-M of 2.2, and an AET of 1.7 ppm, with a moderate degree of confidence in the ER-L and ER-M.

Silver measurements in sediments from the highly polluted Ashtabula River in Ohio had a mean of 6.4 and a range of 2 to 14 ppm (Leonard, 1986), while a study of unpolluted Winnepesaukee River sediments in New Hampshire found up to 6 ppm (Wood, 1984). It should be noted that pollutional classifications of these waters are based on their overall condition and not just the silver content of either the water or sediments.

Sediment silver levels have been measured at a number of other NED projects, but were often too low to quantify. At Thomaston Dam in Connecticut, silver levels were less than detectable (<1.3 ppm) in sediment samples from two stations (NED, 1992b). Silver measurements were made on four sediment samples collected from Birch Hill Dam in Massachusetts; results varied from less than detectable (<0.1) to 2.88, with a mean of 0.86 ppm (NED, 1988b). Two New Hampshire projects were examined: Hopkinton Lake had levels of 0.61 to 0.72 ppm, with a mean of 0.66 (NED, 1988a), and Otter Brook Lake

had less than detectable (<1.3 ppm) at both stations (NED, 1992). The average mean silver concentrations for all other NED projects was 0.8 ppm.

In Hop Brook sediments, concentrations ranged from less than detectable (<1.3 ppm) at station HB05 to 10 ppm at station HB14. The level at station HB05 is typical of expected background concentrations for uncontaminated sediments. However, the level at station HB14 is greater than the ER-L, ER-M, AET, and State of Washington sediment cleanup standards; is higher than any level measured at any other NED project; and in the range found in highly polluted Ashtabula River sediments. On the other hand, sediments at station HB14 have consistently higher levels of heavy metals than those at station HB05. Because it is a trap for fine-grained sediments, station HB14 would be expected to have highest levels of silver. None of the stations at other NED projects were comparable sediment traps. On the whole, it appears that silver concentrations at station HB14 are due to normal processes in the watershed. The absence of detectable levels of silver in waters of Hop Brook Lake is the strongest indication that sediment silver concentrations are not a concern at this project.

(19) Sodium. One of the more common elements, sodium constitutes 2.83 percent (28,300 ppm) of the earth's crust. It is an essential nutrient for humans, but too much is harmful to freshwater aquatic life or terrestrial plants. Because of the extreme solubility of its salts, high levels of sodium are not expected in New England soils without a source such as road salting. Kesler-Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from 75 to 2,660 ppm, with a mean of 1,100 ppm. Other NED projects where sodium levels in sediments have been measured include Thomaston Dam in Connecticut which had 77 to 270 ppm (NED, 1992b), and Otter Brook Lake in New Hampshire which had 64 to 320 ppm (NED, 1992).

With a range of 96 to 250 ppm, sodium levels in Hop Brook soils are within the range of naturally occurring conditions.

(20) Zinc. Table 26 in Appendix B summarizes standards and data for zinc.

Average concentration of zinc in the earth's crustal rocks is given as 50 to 200 ppm (McGraw-Hill). Although it occurs abundantly in rocks and ores, zinc carbonate, oxide, and sulfide are insoluble; consequently, zinc is normally found only in low concentrations in natural waters. Kesler-

Arnold and O'Hearn (1990) found background levels in lower Michigan soils had a range from less than 2.5 to 150 ppm, with a mean of 35 ppm. Miller and McFee (1983) examined surficial soil samples from five areas of industrialized northwestern Indiana; zinc levels ranged from 2,977 in urban soils to 476 ppm in rural soils. At a depth of 30 to 36 centimeters, all soil samples had 8 to 27 ppm zinc.

"Guidelines for the Pollutational Classification of Great Lakes Harbor Sediments" considered zinc levels less than 90 ppm as nonpolluted, 90-200 ppm as moderately polluted, and greater than 200 ppm as heavily polluted.

The Massachusetts Dredging Handbook gives Type I, II, and III classifications for disposal of dredged material. Type I materials are cleanest, and type III are contaminated. Type I material can be placed in unconfined and uncontained upland sites, type II can be used as daily cover at an approved landfill, but type III must be in a confined or contained disposal site. For zinc, type I, II, III limits are <200, 200 - 400, and >400 ppm, respectively (Barr, 1987).

The State of Washington set sediment quality standards for zinc of 410 ppm, and sediment cleanup standards of 960 ppm (Ginn and Pastorok, 1992).

Long and Morgan (1990) reported an ER-L of 120, AET of 260, and an ER-M of 270 ppm with a high degree of confidence in the ER-L and ER-M.

Zinc levels for 598 samples from Gulf of Maine harbor sediments had a mean of 134 and a mean plus two standard deviations of 436 ppm. For 601 samples from dredged harbors from Cape Cod to western Connecticut, mean zinc levels were 283, and the mean plus two standard deviations was 1,010 ppm (NED, 1980a). An analysis of zinc in sediments from 16 lakes in Massachusetts found a mean of 279 and a range of 80 to 843 ppm (Fratoni et al. 1982). The USGS measured 23 to 27 ppm zinc in sediments in the Merrimack River at Nashua, New Hampshire in 1975 (USGS, 1975).

Median zinc levels found in sediments in the 1975 Massachusetts Toxic Element Survey (Isaac and Delaney, 1975) ranged from 480 mg/Kg in the heavily polluted Blackstone River, to 57 mg/Kg in the moderately polluted North River, to 47 mg/Kg in the lightly polluted Quinsigamond River, to 16 mg/Kg in the clean South River. Maximum zinc levels in this study were 4,000, 985, 92, and 17 mg/Kg, respectively, from heavily polluted to clean. Lake Quinsigamond, which was considered clean, had sediments with a median of 410 mg/Kg



and a maximum of 730 mg/Kg of zinc. That clean Lake Quinsigamond had sediments with zinc levels in the range of slightly polluted to heavily polluted river sediments is not surprising as lake sediments seem more likely to trap and retain metals. Also, it should be remembered that these rivers were classified as polluted, based on their general condition and not necessarily their zinc contents.

Highly polluted Ashtabula River sediments had 157 to 604 ppm (Leonard, 1986), and polluted Oxoboxo River sediments had 230 to 3,000 ppm (NED, 1980b). It should be noted, however, that these river sediments were not necessarily polluted with zinc.

Measurements of zinc levels in sediments have been made at two other NED projects. At Thomaston Dam in Connecticut, levels of 140 to 280, with a mean of 210 ppm were found in sediment samples from two stations (NED, 1992b). Otter Brook Lake in New Hampshire had levels of 29 to 85, with a mean of 57 ppm (NED, 1992). The average mean concentrations for other NED projects was 130 ppm.

In Hop Brook sediments, concentrations ranged from 33 ppm at station HB05 to 280 ppm at station HB14. The level at station HB05 is typical of expected background concentrations for uncontaminated sediments. However, the level at station HB14 is greater than the ER-L, ER-M, and AET; is in the category of heavily polluted by the Great Lakes Sediment Classification; and exceeds Massachusetts DEQE Type I sediment classification. On the other hand, it meets State of Washington sediment cleanup standards, is within the range measured at unpolluted Lake Quinsigamond and other NED projects. Sediments at station HB14 have consistently higher levels of heavy metals than those at station HB05. Because it is a trap for fine-grained sediments, station HB14 would be expected to have highest levels of zinc. On the whole, it appears that zinc concentrations at station HB14 are due to normal processes in the watershed. The absence of detectable levels of zinc in waters of Hop Brook Lake are the strongest indication that sediment zinc concentrations are not a concern at this project.

f. Trace Metals in Water. Metals analyses in water at Hop Brook Lake found generally low to nondetectable levels. No metals were found in levels which were a threat to humans or aquatic life at Hop Brook Lake. Levels of total aluminum, antimony, and copper levels exceeded criteria for dissolved fractions of these metals. However, it is unlikely that significant portions of these metals were in soluble forms. Iron and manganese levels exceeded secondary drinking water

criteria which are not a threat to public health but are set to protect public welfare; however, Hop Brook is not used for public water supply, and iron and manganese levels were not a threat to aquatic life. Table 3 is a summary of trace metal analyses at Hop Brook Lake.

Metals which were above detectable concentrations are discussed individually in the following paragraphs.

(1) Aluminum. Measured aluminum levels ranged from 0.25 mg/L at station HB14 to 0.26 mg/L at station HBO5. Connecticut has not set numerical limits for aluminum in freshwater.

Criteria for aluminum in freshwater came from Ambient Water Quality Criteria (FR 1988: 39177). These indicate that freshwater organisms and their uses should not be harmed, when the pH is between 6.5 and 9.0, if the 4-day average concentration of aluminum does not exceed 0.087 mg/L and the 1-hour average concentration does not exceed 0.75 mg/L more than once every three years on the average (FR, 1988). No criteria were estimated for pH outside this range. The pH at Hop Brook Lake varies greatly due to effects of algae blooms which raise pH during the day and drop it at night. Median and mean pH are both about 6.9 SU. Measured aluminum levels at Hop Brook Lake exceeded the chronic criterion but were less than the acute.

The chemistry of aluminum in freshwater is very complex, and the threat posed by it to aquatic life depends on the pH and form of aluminum. For example, although fish kills reported at pHs not regarded as toxic have been attributed to high levels of aluminum (Langdon, 1973), it has also been shown that aluminum can ameliorate the effects on fish of pH below five (Hutchinson et al. 1987). Organically-bound aluminum is much less harmful than dissolved aluminum (Driscoll et al. 1980). Ambient Water Quality Criteria (FR 1988: 39177) recommends measuring acid-soluble aluminum as this is the most likely to include all toxic forms. Acid-soluble aluminum is operationally defined as that passing through a 0.45  $\mu$ m filter after the sample was acidified to a pH between 1.5 and 2.0 with nitric acid.

Total recoverable aluminum was measured at Hop Brook Lake. Results were above the chronic criterion but below the acute, although the pH is frequently outside the range for which criteria were devised. However, aluminum does not appear to be harming aquatic life in the lake, probably due to the aluminum being in a nontoxic state such as organically bound aluminum. Additionally, stresses caused by algae

TABLE 3

DETECTABLE CONCENTRATIONS AT HOP BROOK LAKE  
TRACE METALS IN WATER

<u>Parameter</u>	<u>Station</u>	<u>Media</u>	<u>Concentration</u>	
			<u>Sample</u> (ppm)	<u>Blank</u> (ppm)
Aluminum	HB14	Water	0.25	<0.006
Aluminum	HB05	Water	0.26	
Antimony	HB14	Water	J0.081	<0.009
Antimony	HB05	Water	J0.11	
Barium	HB14	Water	0.020	<0.002
Barium	HB05	Water	0.021	
Calcium	HB14	Water	8.8	<0.001
Calcium	HB05	Water	9.0	
Cobalt	HB14	Water	J0.018	<0.002
Cobalt	HB05	Water	J0.021	
Copper	HB14	Water	J0.0092	<0.006
Copper	HB05	Water	J0.001	
Iron	HB14	Water	0.60	<0.013
Iron	HB05	Water	0.57	
Manganese	HB14	Water	0.017	<0.005
Manganese	HB05	Water	0.10	
Magnesium	HB14	Water	2.7	<0.002
Magnesium	HB05	Water	2.7	
Potassium	HB14	Water	2.4	<0.085
Potassium	HB05	Water	2.6	
Sodium	HB14	Water	12	<0.025
Sodium	HB05	Water	13	

J - Estimated value--analyte detected at less than the practical quantitation limit.

blooms, including fluctuating pH and dissolved oxygen, ensure that aquatic organisms in the lake are tough. Also, aluminum levels at this project are well within the range measured at other NED projects.

Aluminum levels do not appear to be a concern at Hop Brook Lake. There are no point source discharges of aluminum in the watershed and measured levels are likely due to natural background conditions. Other studies are ongoing in NED to determine the actual forms of aluminum present at Corps projects (NED, 1993). If results show a significant portion of aluminum is in potentially toxic forms, the importance of aluminum in the waters of all projects, including Hop Brook Lake, will be reevaluated.

(2) Antimony. Levels of total recoverable antimony in waters of Hop Brook Lake were too low to quantify, but were estimated at 0.081 ppm at station HB14 and 0.110 ppm at station HB05. Connecticut has not set numerical limits for antimony in freshwater to protect sensitive aquatic life, but has set limits of 4.3 ppm to protect human consumers of aquatic organisms (CTDEP, 1992).

Dissolved antimony in freshwater exists in either the +III or +V valence state. Although a number of antimony salts are soluble, the oxides and sulfides are insoluble. Consequently, any dissolved antimony released to freshwater is likely to be removed by precipitation and adsorption (McKee and Wolf).

Criteria for antimony in freshwater came from Ambient Water Quality Criteria (FR 1988: 39177). These indicate that freshwater organisms and their uses should not be harmed if the 4-day average concentration of antimony (III) does not exceed 0.030 ppm, and the one-hour average concentration does not exceed 0.088 ppm more than once every three years on an average. No standard was given for the +V valence state or total antimony.

Although antimony levels at Hop Brook Lake appear to exceed the chronic criteria, and equal or exceed the acute criteria to protect sensitive aquatic life, these criteria are for antimony +III, and total antimony was what was measured. It is likely that the antimony measured at Hop Brook Lake consisted chiefly of suspended antimony-containing mineral particles and little antimony was in the dissolved form. As a check on this assumption, future metal measurements at NED projects will include analyses of dissolved metals.

There are no indications that metals are causing problems to aquatic life at Hop Brook Lake. Therefore, antimony levels are not a concern at this project.

(3) Barium. High concentrations of barium in drinking water can effect the heart and blood vessels; consequently, the U.S. Environmental Protection Agency (EPA) set a primary drinking water standard of 1 mg/L to protect public health. Concentrations measured at Hop Brook are below this standard. Barium is not soluble in natural waters in high enough concentrations to be hazardous to aquatic life; therefore, no aquatic life criteria were set. Measured levels of barium at Hop Brook Lake ranged from 0.020 mg/L at station HB14 to 0.021 mg/L at station HB05. These are well within all water quality standards.

(4) Calcium. The importance of calcium concentrations in water is that, along with magnesium, they are the primary determinants of hardness. Hard waters protect aquatic life from effects of heavy metals, may reduce risks of heart attacks in humans, and have no adverse health effects. Consequently, there are no drinking water standards or aquatic life criteria for hardness. Levels measured at Hop Brook ranged from 8.8 mg/L at station HB14 to 9.0 mg/L at station HB05, indicating the waters are very soft. When magnesium levels are factored in, the average hardness is equivalent to 33 mg/l  $\text{CaCO}_3$ .

(5) Cobalt. There are no standards for cobalt in drinking water or to protect sensitive aquatic life. In trace concentrations, cobalt is an essential nutrient to man and stimulates the growth of some organisms. Cobalt has limited toxicity to man but at elevated concentrations can be toxic to aquatic life. Reports in the literature indicate cobalt concentrations usually have to be above 10 mg/L before toxic effects are observed, although sublethal effects have been noted as low as 0.5 mg/L. Cobalt concentrations at Hop Brook Lake were too low to quantify, but estimated levels ranged from 0.018 mg/L at station HB14 to 0.021 mg/L at station HB05. These are well below levels expected to have adverse effects, and typical of concentrations likely to stimulate aquatic growth.

(6) Copper. Levels of copper at Hop Brook Lake were too low to quantify, and were estimated at 0.0092 ppm at station HB14 to 0.001 ppm at station HB05. Connecticut Water Quality Standards (CTDEP, 1992) give freshwater criteria for dissolved copper of 0.0143 ppm for acute conditions and 0.0048 for chronic conditions. These criteria state that biological integrity is assumed to be compromised when

ambient concentrations exceed the acute criterion more than 5 percent, or the chronic criterion more than 50 percent of days in any year.

The most recent water quality criteria from the USEPA (1986) are hardness dependent. Based on an average hardness of 33 mg/L as  $\text{CaCO}_3$ , the acute criterion is 0.006 ppm and the chronic is 0.005 ppm.

The estimated copper level at station HB05 at Hop Brook Lake of 0.001 ppm meets all applicable criteria. However, the estimated 0.009 ppm at station HB14 exceeds the Connecticut chronic criterion and the USEPA chronic and acute criteria; although, it is under the Connecticut acute criterion. These criteria are for dissolved copper, but total copper was what was measured. It is likely that the copper measured at Hop Brook Lake consisted chiefly of suspended copper-containing mineral particles, and that little copper was in the dissolved form. As a check on this assumption, future metals measurements at NED projects will include analyses of dissolved metals.

There are no indications that metals are causing problems to aquatic life at Hop Brook Lake. Therefore, copper levels are not a concern at this project.

(7) Iron. Water supplies with elevated levels of iron can stain laundry and impart unpleasant taste; consequently, a secondary drinking water standard of 0.3 mg/L was established. Measured levels of iron at Hop Brook Lake ranged from 0.57 mg/L at station HB05 to 0.60 mg/L at station HB14. With a maximum of 0.60 mg/L, iron levels at Hop Brook exceed this criterion. It is not unusual for groundwaters to have naturally occurring high levels of iron. Levels measured at Hop Brook are within the range found in uncontaminated watersheds. At sustained levels of 1 mg/L or more, iron can be toxic to aquatic life; however, maximum measured levels at Hop Brook were well below this criterion.

(8) Manganese. Concerns about manganese in drinking water are similar to those for iron. Manganese in concentrations greater than 0.05 mg/L can cause laundry staining and taste problems in potable waters. This is the origin of the secondary drinking water standard. Like barium, manganese is not soluble in natural waters at concentrations high enough to be harmful to aquatic life. Consequently, no aquatic life criteria have been established for manganese. Measured levels of manganese at Hop Brook Lake ranged from 0.10 mg/L at station HB05 to 0.17 mg/L at station HB14. These levels exceed secondary drinking water criteria but are no threat to

aquatic life and are typical of naturally occurring conditions.

(9) Magnesium. After calcium, magnesium is the primary determinate of the hardness of water. Hard waters protect aquatic life from effects of heavy metals, may reduce the risks of heart attacks in humans, and do not have adverse health effects. Consequently, there are no drinking water standards or aquatic life criteria for hardness. Measured magnesium levels at Hop Brook Lake were 2.7 mg/L at stations HB05 and HB14, indicating the waters are very soft.

(10) Potassium. There are no drinking water or aquatic life criteria for potassium. An essential nutrient and one of the more common elements in the earth's crust, potassium is harmful only at elevated concentrations. In drinking water, potassium chloride has a taste threshold at 180 mg/L of potassium; however, it may be the chloride that was noticed. In freshwater, the toxicity of potassium is greatly affected by the presence of other compounds, particularly calcium. Generally, adverse effects are not noticed below 50 mg/L of potassium. With a range of 2.4 mg/L at station HB14 to 2.6 mg/L at station HB05, potassium levels at Hop Brook Lake are not harmful and typical of expected background concentrations.

(11) Sodium. At elevated concentrations in drinking water, sodium may be a risk for people with hypertension. However, EPA feels the population at risk is too small to justify placing Federal limits on permissible sodium concentrations in public drinking waters. EPA felt it was more practical for people with hypertension to purchase bottled salt-free water. Consequently, there are no Federal drinking water limits for sodium.

Although there are no established criteria to protect sensitive aquatic life, high levels of sodium are harmful. However, with a range of 12 mg/L at station HB14 to 13 mg/L at station HB05, the low levels measured in Hop Brook are typical of natural conditions and no threat to aquatic life.

g. Volatile Organic Compounds. The only detectable levels of volatile organics found in water or sediments were acetone, methylene chloride, and 2-butanone. None were in concentrations high enough to be of concern. Table 4 is a summary of volatile organic analyses at Hop Brook Lake.

(1) Acetone and Methylene Chloride. These compounds were reported in both media and blank samples at levels equal to or greater than those in test samples. This indicates the

TABLE 4

DETECTABLE CONCENTRATIONS AT HOP BROOK LAKE  
VOLATILE ORGANICS

<u>Parameter</u>	<u>Station</u>	<u>Media</u>	<u>Concentration</u>	
			<u>Sample</u> (ppm)	<u>Blank</u> (ppm)
Acetone	HB14	Water	J0.030	J0.051
Acetone	HB05	Water	J0.036	J0.025
Acetone*	HB14	Sediment	6.5	J0.047
Acetone	HB05	Sediment	J0.053	
Methylene Chloride	HB14	Water	0.011	0.019
Methylene Chloride	HB05	Water	0.011	0.012
Methylene Chloride	HB14	Sediment	0.0097	<0.019
Methylene Chloride	HB05	Sediment	0.0051	
2-Butanone	HB14	Water	<0.1	<0.1
2-Butanone	HB05	Water	<0.1	
2-Butanone	HB14	Sediment	U0.472	<0.1
2-Butanone	HB05	Sediment	<0.089	

J - Estimated value--analyte detected at less than the practical quantitation limit

\* Dilution factor for this analyte was 277



probable origin of these compounds was sample contamination or laboratory error. Both compounds are notorious laboratory artifacts.

(2) 2-Butanone. More commonly known as "methyl ethyl ketone," is extensively used as a solvent in industrial processes. Additional uses include as a fragrance and flavoring agent in candy and perfumes, and a sterilizer for medical instruments (HSDB, 1992). Naturally occurring sources include volcanos, forest fires, biological degradation of organic matter, and foodstuffs (Graedel, 1978, and Lande, 1976). High atmospheric levels are formed as a component of photochemical smog; however, it is generally absent from ambient air (HSDB, 1992).

Methyl ethyl ketone (MEK) has little affinity for particulate matter and will evaporate quickly if spilled on soil. It is soluble in water, but will evaporate with an expected half life of 3 to 12 days. MEK biodegrades slowly and is not expected to bioconcentrate (HSDB, 1992). Little information is available on background concentrations in soils or sediments.

No standards for MEK have been set for drinking water, air emissions, or to protect freshwater or marine organisms. The reportable release quantity under CERCLA is 5,000 pounds (IRIS, 1993).

Levels of MEK in water and soils at other NED projects have generally been below detectable concentrations. In 1 of 2 sediment samples examined from Thomaston Dam, the MEK concentration was too low to quantify but was estimated at 0.035 ppm; the other sample had less than detectable levels, with a method detection limit of 0.287 ppm in the sample and 0.1 ppm in the method blank (NED, 1992b). Because the estimated level of 0.035 ppm in the sediment was below the detection limit in the blank, it is unlikely that any MEK was actually measured (Condiak, 1993).

At Hop Brook Lake, MEK concentrations in sediments at station HB05 were less than detectable (<0.089 ppm), compared to a detection limit of 0.1 ppm in the method blank. However, at station HB14, the level in the sediment sample was reported as greater than the upper calibration limit of 0.47 ppm. The most likely source of MEK at station HB14 is the biological degradation of organic material. This MEK should be reduced over time by dissolution and volatilization, and biological degradation. It is unlikely that MEK is a problem at this project.

h. Semivolatile Organic Compounds--Water. Table 5 is a summary of semivolatile organic analyses at Hop Brook Lake. The only semivolatile organic compound detected in water samples from Hop Brook Lake was di-n-octyl phthalate. This compound is a plasticizer and a common laboratory contaminant. Reported concentrations for Hop Brook Lake water samples were 0.0016 ppm at station HB14, 0.02 ppm at station HB05, and 0.0059 ppm in the method blank. Connecticut has no standards for di-n-octyl phthalate in water (CTDEP, 1993). In the Gold Book (EPA, 1986), there are no criteria to protect sensitive freshwater aquatic life for phthalate esters, only a notation that the lowest effects levels are 0.94 ppm for acute and 0.003 ppm for chronic conditions. Inasmuch as reported levels were similar to detectable levels found in the blank, and that di-n-octyl phthalate is a common plasticizer, it is highly unlikely that di-n-octyl phthalate levels at Hop Brook Lake are cause for concern.

i. Semivolatile Organic Compounds--Sediment. A number of semivolatile organic compounds were detected in sediment samples from Hop Brook Lake. Many were also detected in blank samples or found at levels very close to the laboratory detection limit. None were in harmful concentrations. Most detected compounds were either polynuclear aromatic hydrocarbons (PAHs) or phthalate esters. PAHs are ubiquitous products of incomplete combustion, and phthalate esters are plasticizers. Compounds reported in greater than detectable concentrations in sediment are discussed in the following sections. Compounds are grouped together by class.

(1) Polynuclear Aromatic Hydrocarbons

(a) Acenaphthene. Table 27 in Appendix B summarizes standards and data for acenaphthene.

This PAH is a component of crude oil and a product of combustion, which may be produced and released to the environment during natural fires, petroleum refining, coal tar distillation, coal combustion, and internal combustion engines (HSDB, 1992). Its use and release to the environment are widespread.

Acenaphthene is naturally biodegradable when released to the environment. In water, it will attach to organic compounds and clays, and may also volatilize to the atmosphere. In soils, it binds to organic compounds and clays, but may be mobile in mineral soils.

No drinking water standards or freshwater aquatic life criteria have been established for acenaphthene.

TABLE 5

DETECTABLE CONCENTRATIONS AT HOP BROOK LAKE  
SEMIVOLATILE ORGANICS

Parameter	Station	Media	Concentration	
			Sample (ppm)	Blank (ppm)
PAHs				
Acenaphthene	HB05	Soil	<0.042	<0.033
Acenaphthene	HB14	Soil	J 0.015	<0.033
Acenaphthylene	HB05	Soil	J 0.0088	<0.033
Acenaphthylene	HB14	Soil	J 0.027	<0.033
Anthracene	HB05	Soil	J 0.038	<0.033
Anthracene	HB14	Soil	J 0.072	<0.033
Benzo(a)anthracene	HB05	Soil	0.15	<0.033
Benzo(a)anthracene	HB14	Soil	0.42	<0.033
Benzo(a)pyrene	HB05	Soil	0.12	<0.033
Benzo(a)pyrene	HB14	Soil	0.42	<0.033
Benzo(b)fluoranthene	HB05	Soil	0.16	<0.033
Benzo(b)fluoranthene	HB14	Soil	0.45	<0.033
Benzo(k)fluoranthene	HB05	Soil	0.16	<0.033
Benzo(k)fluoranthene	HB14	Soil	0.45	<0.033
Benzo(g,h,i)perylene	HB05	Soil	<0.042	<0.033
Benzo(g,h,i)perylene	HB14	Soil	0.29	<0.033
Chrysene	HB05	Soil	0.22	<0.033
Chrysene	HB14	Soil	0.63	<0.033
Fluoranthene	HB05	Soil	0.24	<0.033
Fluoranthene	HB14	Soil	0.99	<0.033
Fluorene	HB05	Soil	J 0.022	<0.033
Fluorene	HB14	Soil	J 0.047	<0.033
Indeno(1,2,3-cd)pyrene	HB05	Soil	J 0.042	<0.033
Indeno(1,2,3-cd)pyrene	HB14	Soil	0.68	<0.033
2-Methylnaphthalene	HB05	Soil	J 0.011	<0.033
2-Methylnaphthalene	HB14	Soil	J 0.024	<0.033

TABLE 5 (CONT.)

DETECTABLE CONCENTRATIONS AT HOP BROOK LAKE  
SEMIVOLATILE ORGANICS

<u>Parameter</u>	<u>Station</u>	<u>Media</u>	<u>Concentration</u>	
			<u>Sample</u> (ppm)	<u>Blank</u> (ppm)
<u>PAHs</u>				
Naphthalene	HB05	Soil	J 0.014	<0.033
Naphthalene	HB14	Soil	J 0.030	<0.033
Phenanthrene	HB05	Soil	0.30	<0.033
Phenanthrene	HB14	Soil	0.59	<0.033
Pyrene	HB05	Soil	0.64	<0.033
Pyrene	HB14	Soil	2.0	<0.033
<u>Phthalate Esters</u>				
Bis(2ethylhexyl)phthalate	HB05	Soil	0.41	<0.033
Bis(2ethylhexyl)phthalate	HB14	Soil	0.52	<0.033
Diethylphthalate	HB05	Soil	0.29	<0.033
Diethylphthalate	HB14	Soil	0.22	<0.033
Di-n-butylphthalate	HB05	Soil	0.32	0.090
Di-n-butylphthalate	HB14	Soil	0.62	0.090
Di-n-octyl phthalate	HB05	Soil	<0.042	
Di-n-octyl phthalate	HB14	Soil	0.26	0.027
Di-n-octyl phthalate	HB05	Water	0.020	0.0059
Di-n-octyl phthalate	HB14	Water	0.0016	0.0059
<u>Miscellaneous</u>				
Dibenzofuran	HB05	Soil	J 0.0095	<0.033
Dibenzofuran	HB14	Soil	J 0.022	<0.033

J - Estimated value--analyte detected at less than  
the practical quantitation limit

The lowest reported toxic concentrations for freshwater aquatic organisms was 1.7 mg/L as an acute condition and 0.52 mg/L as a chronic condition (Walker).

Long and Morgan (1990) reported an AET of 0.15 ppm, an ER-L of 0.15, and an ER-M of 0.65 ppm, with a low degree of confidence in the ER-L and ER-M.

Neither EPA nor CTDEP have established criteria for acenaphthene in sediment. The State of Washington set sediment quality standards of 16 ppm and sediment cleanup standards of 57 ppm acenaphthene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment quality standards become 3.2 and 12, and cleanup standards become 1.6 and 5.7 ppm for HB14 and HB05, respectively.

Detectable levels of acenaphthene have been measured in sediments by a number of researchers. Coastal Washington State sediments taken from the Duwamish River delta in Washington, Eagle Harbor, and President Point had acenaphthene average concentrations ranging from less than 0.002 to 5 ppm. The log mean of these means was 0.094 ppm (Varanasi et al. 1985, and Malins et al. 1985). Three sediment samples from New York Harbor contained acenaphthene in amounts of 0.08, 0.5, and 0.5 ppm; the mean was 0.34 ppm (Farrington and Westfall, 1986). Larsen et al. (1983) detected acenaphthene in 5 of 30 samples from Casco Bay, Maine at concentrations ranging from 0.34 to 1.15, with a mean of 0.85 ppm. Plowchalk and Zagorski (1986) found detectable levels of acenaphthene in 8 of 10 sediment samples from streams feeding Lake Erie within the city of Erie, Pennsylvania, at concentrations ranging from 0.175 to 3.37 ppm; the mean of detectable concentrations was 0.84 ppm.

Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average acenaphthene concentrations of 0.0536 ppm in polluted soils, 0.0017 ppm in nonpolluted soils, and 0.0038 in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether the high organic content of soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Other NED projects where acenaphthene was measured in sediments include Otter Brook Lake in New Hampshire and Thomaston Dam in Connecticut. Otter Brook's sediments are typical of clean background conditions due to the low level of development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated

conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of acenaphthene. Two samples were examined at Otter Brook Lake, and acenaphthene levels were less than the detection limit of 0.053 ppm (NED, 1992b). At Thomaston Dam, acenaphthene levels in two samples were too low to quantify, and were estimated at 0.024 to 0.057 ppm (NED, 1992).

Acenaphthene was not detected at station HB05 (<0.042 ppm). At station HB14, the level in the sediment sample was too low to quantify and was estimated at 0.015 ppm. This level was actually below the detection level of 0.033 ppm in the method blank. Dr Mark Anthony, formerly of the Ohio River Division (ORD), believed if a compound were not measured above 10 times the detection limit, it was not a confirmed finding. Because the estimated level was below the detection limit in the blank, it is questionable whether it was actually detected.

The estimated 0.015 ppm level of acenaphthene at station HB14 is below the ER-L, ER-M, AET, Washington State sediment standards, and lowest effects concentrations for freshwater aquatic life. It is also within the range of other NED projects. For these reasons, acenaphthene levels at Hop Brook Lake are determined very low and not an indication of watershed contamination.

(b) Acenaphthylene. Table 28 in Appendix B summarizes standards and data for acenaphthylene.

A polynuclear aromatic hydrocarbon (PAH) and a component of crude oil and coal tar, acenaphthylene is produced and released during petroleum refining and coal tar distillation. It is also produced during forest fires. Used in the manufacture of dyes, plastics, insecticides, and fungicides, its use and release to the environment are widespread.

Acenaphthylene is naturally biodegradable when released to the environment. In water, it will attach to organic compounds and clays, and may also volatilize to the atmosphere. In soils, it binds to organic compounds and clays, but may be mobile in mineral soils.

No drinking water standards or freshwater aquatic life criteria have been established for acenaphthylene. The lowest acute concentration observed to have an effect on aquatic life was 0.3 mg/L (IRIS, 1992). For acenaphthene, a related compound, lowest reported toxic concentrations for

freshwater aquatic organisms was 1.7 mg/L as an acute condition and 0.52 mg/L as a chronic condition (Walker).

Neither EPA nor CTDEP have established criteria for acenaphthylene in sediment. The State of Washington set sediment quality standards of 66 ppm and sediment cleanup standards of 66 ppm acenaphthylene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 13 and 13, and cleanup standards become 6.6 and 6.6 ppm for HB14 and HB05, respectively.

Detectable levels of acenaphthylene have been measured in sediments by a number of researchers. One of three sediment samples from New York Harbor contained detectable acenaphthylene in the amount of 0.03 ppm (Farrington and Westfall, 1986). Larsen et al. (1983) detected acenaphthylene in 2 of 30 samples from Casco Bay, Maine, at concentrations of 0.165 and 1.87 ppm. Plowchalk and Zagorski (1986) found detectable acenaphthylene in only 1 of 10 sediment samples from streams feeding Lake Erie within Erie, Pennsylvania, at a concentration of 3.26 ppm. Staples et al. (1985) examined the EPA STORET data base and found that acenaphthylene had a median concentration of less than 0.5 ppm and tested positive in 6 percent of 359 sediment samples.

Other NED projects where acenaphthylene was measured in sediments include Otter Brook Lake in New Hampshire and Thomaston Dam in Connecticut. Otter Brook's sediments are typical of clean background conditions due to the low level of development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of the sediments and not necessarily to levels of acenaphthylene. Two samples were examined at Otter Brook Lake and acenaphthylene was less than the detection limit of 0.051 ppm in one sample, and too low to quantify, but estimated at 0.016 ppm in the other (NED, 1992b). At Thomaston Dam, acenaphthylene levels in two samples were too low to quantify, and were estimated at 0.042 to 0.054 ppm (NED, 1992).

Acenaphthylene at Hop Brook Lake was detected in sediment samples at levels too low to quantify, and was estimated at 0.027 ppm at station HB14 and 0.0088 ppm at station HB05. These levels were actually below the detection level of 0.033 ppm in the method blank. Dr Mark Anthony, formerly of ORD, believed if a compound were not measured

above 10 times the detection limit, it was not a confirmed finding. Because estimated levels were below the detection limit in the blank, it is questionable whether acenaphthylene was actually detected.

Acenaphthylene levels at Hop Brook Lake are low, within the range detected at other NED projects, indicative of natural background levels in the watershed, and not a cause for concern.

(c) Anthracene. Table 29 in Appendix B summarizes standards and data for anthracene.

This PAH is a natural product of incomplete combustion and, consequently, ubiquitous in the environment. McKee and Wolf report, "Used as an important source of dyestuffs, this solid hydrocarbon is insoluble in water although it can be dissolved in alcohol and other organic solvents." It strongly adsorbs to sediment and is not mobile in the soil, and is quickly removed from water by adsorption. Biodegradation can occur rapidly in soils with microbes acclimated to PAHs.

No criteria have been established for anthracene in drinking water, to protect freshwater aquatic life, or for sediments. Nor are data available for lowest effects concentration (LEC) in freshwater. However, LEC data for acute conditions in marine water are 0.3 mg/L (IRIS, 1992). Long and Morgan (1990) report an ER-L of 0.085, an ER-M of 0.96, and an overall AET of 0.30 ppm, with low confidence in the ER-L and moderate confidence in the ER-M for anthracene.

Neither EPA nor CTDEP have established criteria for anthracene in sediment. The State of Washington set sediment quality standards of 220 ppm and sediment cleanup standards of 1,200 ppm anthracene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment quality standards become 44 and 240, and cleanup standards become 22 and 120 ppm for HB14 and HB05, respectively.

For PAHs as a class, carcinogenicity protection, equal to a one-in-a-million lifetime increased risk, was estimated to be achieved at a level of 0.0000028 ppm for ingestion of water and organisms living in that water, while 0.00003 ppm was estimated for ingestion of organisms alone. However, it is extremely difficult to estimate criteria from carcinogenicity protection guidelines. Invariably, adopted drinking water and freshwater aquatic life criteria are orders of magnitude higher than carcinogenicity protection guidelines.



Concentrations reported for New England area soils and sediments include 0.170 ppm in Buzzards Bay sediments (Goodley), detection in 16 of 24 Boston Harbor sediments at 0.008 to 0.507 ppm (Shiaris), and detection in 46 of 96 coast of Maine sediments at concentrations up to 0.008 ppm (Larsen).

Anthracene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to the low level of development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of anthracene. Concentrations in two samples at Thomaston Dam ranged from 1.2 to 1.9 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was too low to quantify but estimated at 0.056 ppm; at the other station the measured concentration was 0.39 ppm (NED, 1992).

Anthracene was detected in sediment samples at both Hop Brook Lake stations but at levels too low to quantify. Estimated concentrations ranged from 0.038 ppm at station HB05 to 0.072 ppm at station HB14. These levels were not greatly above the detection level of 0.033 ppm. Dr. Mark Anthony, formerly of ORD, believed that if a compound were not measured above 10 times the detection limit, it was not a confirmed finding. Because the estimated level is close to the detection limit, it is questionable whether it was actually detected.

At a range of 0.038 ppm to 0.072 ppm, measured levels at Hop Brook Lake are well below the AET, ER-L, ER-M, and Washington State sediment standards. It is also well within the range found at other NED projects. Because of the low levels found at Hop Brook, its ubiquitousness in the environment, its strong affinity for sediments, and limited mobility, and that natural biodegradation can be expected to remove it, anthracene is not a concern at Hop Brook Lake.

(d) Benzo(a)anthracene. Table 30 in Appendix B summarizes standards and data for benzo(a)anthracene.

This PAH, also known as "benz(a)anthracene," is widespread in the environment due to its release as an incomplete combustion product of organic matter. It strongly binds to sediments and is rapidly removed from the water column by adsorption. It bioconcentrates in aquatic organisms and degrades slowly when attacked by microorganisms acclimated to PAHs (HSDB, 1992).

Criteria have not been established for benzo(a)-anthracene in drinking water; however a maximum contaminant level goal of 0.0002 mg/L has been proposed. Criteria have not been established to protect freshwater aquatic life. The closest to an aquatic criterion is an LEC for marine organisms for acute conditions of 0.3 ppm. For PAHs as a class, carcinogenicity protection equal to a one-in-a-million lifetime increased risk, was estimated to be achieved at a level of 0.0000028 ppm for ingestion of water and organisms living in that water, while 0.00003 ppm was estimated for ingestion of organisms alone. However, it is extremely difficult to estimate criteria from carcinogenicity protection guidelines. Invariably, adopted drinking water and freshwater aquatic life criteria are orders of magnitude higher than carcinogenicity protection guidelines.

No criteria have been established for benzo(a)-anthracene in sediments. Long and Morgan (1990) report an ER-L of 0.23, an ER-M of 1.6, and an overall AET of 0.55 ppm, with a low degree of confidence in the ER-L and a moderate degree of confidence in the ER-M.

Neither EPA nor CTDEP have established criteria for benz(a)anthracene in sediment. The State of Washington set sediment quality standards of 110 ppm and sediment cleanup standards of 270 ppm benz(a)anthracene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment quality standards become 22 and 54, and cleanup standards become 11 and 27 ppm for HB14 and HB05, respectively.

Benzo(a)anthracene has been measured in soil and sediment at a few sites in North America. Sampling of two remote Adirondack Lakes found 0.078 to 0.36 ppm in surficial sediments (Tan and Heit). On the other hand, soils near traffic highways had 1.5 ppm and soil contaminated with coal-tar pitch had 2.5 ppm (IARC). Sampling of New England area sediments found 0.33 ppm in Buzzards Bay, 0.15 miles from shore, and 0.041 ppm, 1.3 miles from shore; samples from the Atlantic Ocean Shelf had 0.0036 to 0.0061 ppm (Santodonato).

Benzo(a)anthracene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall

condition of sediments and not necessarily to benzo-(a) anthracene levels. Concentrations in two samples at Thomaston Dam ranged from 0.68 to 1.6 ppm (NED, 1992b). At Otter Brook Lake, concentration at one station was too low to quantify but estimated at 0.028 ppm; at the other station, the measured concentration was 0.18 ppm (NED, 1992).

Sediment benzo(a)anthracene levels at Hop Brook Lake ranged from 0.15 ppm at station HB05 to 0.42 ppm at station HB14. These levels are below the ER-M and AET, although the level at station HB14 slightly exceeds the ER-L of 0.23 ppm. The level at station HB14 also exceeds concentrations found in clean Otter Brook Lake sediments, while being less than lightly contaminated ones at Thomaston Dams. Station HB14 is a natural trap for fine-grained sediments, and shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Benzo(a)anthracene levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is further indication that benzo(a)anthracene is not a concern at this project.

(e) Benzo(a)pyrene. Table 31 in Appendix B summarizes standards and data for benzo(a)pyrene.

An ubiquitous product of incomplete combustion, this PAH binds strongly to particulates and is rapidly removed from the water column by adsorption. It bioconcentrates in higher organisms which are unable to metabolize it, but is biodegraded by acclimated microorganisms (HSDB, 1992).

No drinking water, freshwater aquatic life, or sediment criteria have been established; however, there is a proposed drinking water MCL of 0.0002 ppm. Data are not available for lowest effects concentration (LEC) in freshwater. However, LEC data for acute conditions in marine water are 0.3 mg/L (IRIS, 1992). Long and Morgan (1990) report an ER-L of 0.40, an ER-M of 2.5, and an overall AET of 0.70 ppm, with moderate confidence in the ER-L and ER-M.

Neither EPA nor CTDEP have established criteria for benzo(a)pyrene in sediment. The State of Washington set sediment quality standards of 99 ppm and sediment cleanup standards of 210 ppm benzo(a)pyrene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment quality standards become 20 and 42, and cleanup standards become 9.9 and 21 ppm for HB14 and HB05, respectively.

For PAHs as a class, carcinogenicity protection, equal to a one-in-a-million lifetime increased risk, was estimated to be achieved at a level of 0.0000028 ppm for ingestion of water and organisms living in that water, while 0.00003 ppm was estimated for ingestion of organisms alone. However, it is extremely difficult to estimate criteria from carcinogenicity protection guidelines. Invariably, adopted drinking water and freshwater aquatic life criteria are orders of magnitude higher than carcinogenicity protection guidelines.

Edwards (1983) measured benzo(a)pyrene in soils in six countries in areas remote from industrial emissions or vehicular traffic, and found 0.0015 to 1.3 ppm. Santodonato et al. (1981) measured forest soils in Massachusetts and eastern Connecticut and found 0.04 to 1.3 ppm. On the other hand, Santodonato (1980) reported 0.1 to 3 ppm from three highly polluted sites in Naples, Italy, and 0.35 to 11 ppm from three industrial sites in Moscow, Russia. Highest levels found were from the Niagara River where Kuntz (1984) reported 0.19 to 20 ppm.

Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average benzo(a)pyrene concentrations of 0.321 ppm in polluted soils, 0.0145 ppm in nonpolluted soils, and 0.156 ppm in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether high organic content of the soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Benzo(a)pyrene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of benzo(a)pyrene. Concentrations in two samples at Thomaston Dam ranged from 0.56 to 1.3 ppm (NED, 1992b). At Otter Brook Lake, concentration at one station was too low to quantify but estimated at 0.015 ppm; at the other station, the measured concentration was 0.12 ppm (NED, 1992).

Benzo(a)pyrene levels in sediments at Hop Brook Lake ranged from 0.12 ppm at station HB05 to 0.42 ppm at station HB14. These levels are below the ER-M and AET,

although the level at station HB14 slightly exceeds the ER-L of 0.40 ppm. The level at station HB14 also exceeds concentrations found in clean Otter Brook Lake sediments, while being less than lightly contaminated ones at Thomaston Dam. Station HB14 is a natural trap for fine-grained sediments and shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Benzo(a)pyrene levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is further indication that benzo(a)pyrene is not a concern at this project.

(f) Benzofluoranthene. Table 32 in Appendix B summarizes standards and data for benzofluoranthene.

Two forms of this PAH were measured, including benzo(b)fluoranthene and benzo(k)fluoranthene. Both are products of incomplete combustion of organic materials including coal, oil, and forests. They bind strongly to particulates and are rapidly removed from water by adsorption. Biodegradation occurs in the presence of microorganisms adapted to PAHs; however, it occurs slowly. Bioconcentration may occur in higher organisms, especially those lacking microsomal oxidase, an enzyme capable of metabolizing PAHs (HSDB, 1992).

No water quality standards for benzofluoranthenes have been established for drinking water, freshwater, or sediments, although a MCL of 0.0002 mg/L has been proposed. Data are not available for lowest effects concentration (LEC) in freshwater, but LEC data for acute conditions in marine water are 0.3 mg/L (IRIS, 1992).

For PAHs as a class, carcinogenicity protection, equal to a one-in-a-million lifetime increased risk, was estimated to be achieved at a level of 0.0000028 ppm for ingestion of water and organisms living in that water, while 0.00003 ppm was estimated for ingestion of organisms alone. However, it is extremely difficult to estimate criteria from carcinogenicity protection guidelines. Invariably, adopted drinking water and freshwater aquatic life criteria are orders of magnitude higher than carcinogenicity protection guidelines.

Neither EPA nor CTDEP have established criteria for benzofluoranthenes in sediment. The State of Washington set sediment quality standards of 230 ppm and sediment cleanup standards of 450 ppm total benzofluoranthenes (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration

of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 46 and 90, and cleanup standards become 23 and 45 ppm for HB14 and HB05, respectively.

Surficial sediments from Sagamore Lake in a remote part of the Adirondacks had 0.001 to 0.36 ppm benzo(b)fluoranthene and 0.12 to 0.56 ppm benzo(k)fluoranthene (Tan and Heit). Johnson et al. measured 0.017 to 1 ppm benzo(b)fluoranthene in surficial sediments in Penobscot Bay, but did not measure benzo(k)fluoranthene.

Benzofluoranthenes were measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of benzofluoranthene. Two sediment samples were measured at Thomaston Dam; results showed 0.67 to 1.5 ppm benzo(b)- and 0.66 to 1.5 ppm benzo(k)fluoranthene. At Otter Brook Lake, concentrations at one station were too low to quantify but estimated at 0.018 ppm benzo(b)- and 0.017 ppm benzo(k)fluoranthene; at the other station, measured concentrations were 1.5 ppm for both forms of benzofluoranthene (NED, 1992).

Identical levels of benzo(b)fluoranthene and benzo(k)fluoranthene were detected in the two sediment samples from Hop Brook Lake. Benzo(b)- and benzo(k)-fluoranthene were measured at 0.16 ppm at station HB05. At station HB14, benzo(b)- and benzo(k)fluoranthene were measured at 0.45 ppm.

Levels of benzofluoranthenes in sediments at Hop Brook Lake are low and typical of background concentrations. They are orders of magnitude below Washington State cleanup levels, and in the range found at remote Adirondack Lakes. Levels found at station HB14 are closer to those measured in lightly contaminated Thomaston Dam sediments than clean ones at Otter Brook Lakes; however, station HB14 is a trap for fine-grained sediments of the sort that would be likely to bind to benzofluoranthenes. Station HB14 generally has higher levels of potential contaminants that adsorb to fine-grained sediments. Benzofluoranthenes are not a concern at this project.

(g) Benzo(g,h,i)perylene. Table 33 in Appendix B summarizes standards and data for benzo(g,h,i)perylene.

An ubiquitous product of incomplete combustion, this PAH binds strongly to particulates and is rapidly removed from the water column by adsorption. It bioconcentrates in higher organisms and is slowly biodegraded by acclimated microorganisms (HSDB, 1992).

No drinking water, freshwater aquatic life, or sediment criteria have been established, nor are data available for lowest effects concentration (LEC) in freshwater. However, LEC data for acute conditions in marine water are 0.3 mg/L (IRIS, 1993).

For PAHs as a class, carcinogenicity protection, equal to a one-in-a-million lifetime increased risk, was estimated to be achieved at a level of 0.0000028 ppm for ingestion of water and organisms living in that water, while 0.00003 ppm was estimated for ingestion of organisms alone. However, it is extremely difficult to estimate criteria from carcinogenicity protection guidelines. Invariably, adopted drinking water and freshwater aquatic life criteria are orders of magnitude higher than carcinogenicity protection guidelines.

Neither EPA nor CTDEP have established criteria for benzoperylene in sediment. The State of Washington set sediment quality standards of 31 ppm and sediment cleanup standards of 78 ppm total benzoperylene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment quality standards become 6.2 and 16, and cleanup standards become 3.1 and 7.8 ppm for HB14 and HB05, respectively.

Detectable levels of benzoperylene have been measured in sediments by a number of researchers. Coastal sediments taken from various sites in Washington State contained average concentrations ranging from less than 0.023 to 0.58 ppm (Varanasi et al. 1985, and Malins et al. 1985). Garrigues et al. (1987) found that 4 of 5 sediment samples from the Golfe de Gascogne in France had detectable concentrations ranging from 0.001 to 1.97 ppm, with a mean of 610 ppm. Staples et al. (1985) examined the EPA STORET data base and found that detectable levels of benzoperylene had a median concentration of less than 0.5 ppm, and tested positive in 8 percent of 343 sediment samples.

Benzoperylene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam,

on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of benzoperylene. Concentrations in two samples at Thomaston Dam ranged from 0.33 to 0.81 ppm (NED, 1992b). At Otter Brook Lake, concentrations at both stations were less than 0.051 ppm (NED, 1992).

Benzoperylene levels in sediments at Hop Brook Lake ranged from less than detectable (<0.042 ppm) at station HB05 to 0.29 ppm at station HB14. These levels are low. The level at station HB14 exceeds concentrations found in clean Otter Brook Lake sediments, while being less than lightly contaminated ones at Thomaston Dams. Station HB14, a natural trap for fine-grained sediments, shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Benzoperylene levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is a further indication that benzo(g,h,i)perylene is not a concern at this project.

(h) Chrysene. Table 34 in Appendix B summarizes standards and data for chrysene.

An ubiquitous product of incomplete combustion, including forest fires and internal combustion engines, this PAH strongly binds to particulates. Consequently, it is quickly removed from water by adsorption and has little mobility in soils. It is biodegradable by acclimated micro-organisms, but will bioaccumulate in some higher organisms.

Water quality standards for chrysene have not been established for drinking water, freshwater, or sediments, although a MCL of 0.0002 mg/L has been proposed. Data are not available for lowest effects concentration (LEC) in freshwater, but LEC data for acute conditions in marine water are 0.3 mg/L (IRIS, 1992). Long and Morgan (1990) report an ER-L of 0.40, an ER-M of 2.8, and an overall AET of 0.90 ppm with a moderate degree of confidence in the ER-L and ER-M.

Neither EPA nor CTDEP have established criteria for chrysene in sediment. The State of Washington set sediment quality standards of 110 ppm and sediment cleanup standards of 460 ppm chrysene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment



quality standards become 22 and 92, and cleanup standards become 11 and 46 ppm for HB14 and HB05, respectively.

Analyses of sediments in unpolluted areas found levels up to 1.5 ppm. Measurements of surficial sediments in remote Adirondack lakes found 0.19 to 0.89 ppm (Tan and Heit). Verschueren reported 0.023 ppm in sediment from Wilderness Lake, Ontario. Sampling of seven stations in the Australian Great Barrier Reef found <0.0006 to 1.5 ppm (Prahl and Carpenter).

Only two studies of chrysene in New England sediments were located. Sims and Overcash reported that estuarine sediment from Buzzards Bay had 0.24 ppm, 0.5 mile from shore, and 0.04 ppm at a distance of 1.3 miles from shore. Hites et al. sampled one station in the Charles River Basin and found 21 ppm chrysene.

Chrysene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of chrysene. Concentrations in two samples at Thomaston Dam ranged from 0.88 to 1.9 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was too low to quantify but estimated at 0.03 ppm; at the other station, 0.22 ppm were measured (NED, 1992).

Sediment chrysene concentrations at Hop Brook Lake ranged from 0.22 ppm at station HB05 to 0.63 ppm at station HB14. These levels are below the ER-M and AET, although the level at station HB14 exceeds the ER-L of 0.40 ppm. The level at station HB14 also exceeds concentrations found in clean Otter Brook Lake sediments, while being less than lightly contaminated ones at Thomaston Dam. Station HB14 is a natural trap for fine-grained sediments and shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Chrysene levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is a further indication that chrysene is not a concern at this project.

(i) Fluoranthene. Table 35 in Appendix B summarizes standards and data for fluoranthene.

This PAH is widespread in the environment because it is a universal product of incomplete combustion, including natural sources such as forest fires. It absorbs strongly to particles and will be quickly removed from the water column and have limited mobility in soils. It bio-concentrates in aquatic organisms, but will biodegrade in the presence of acclimated micro-organisms (HSDB, 1992). A derivative of coal tar, it is considered insoluble in water (Merck).

No drinking water standards have been established for fluoranthene. For toxicity protection, a level of 0.042 ppm was estimated for ingestion of water and organisms living in that water, while 0.054 ppm was estimated for ingestion of organisms alone. To protect freshwater aquatic life, an acute criterion of 3.98 ppm is given (IRIS, 1992). No criteria have been developed for fluoranthene in sediments. Long and Morgan (1990) report an ER-L of 0.60, an ER-M of 3.6, and an overall AET of 1.0 ppm, with a high degree of confidence in the ER-L and ER-M.

Neither EPA nor CTDEP have established criteria for fluoranthene in sediment. The State of Washington set sediment quality standards of 160 ppm and sediment cleanup standards of 1,200 ppm for fluoranthene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 32 and 240, and cleanup standards become 16 and 120 ppm for HB14 and HB05, respectively.

Fluoranthene has been measured in soil or sediment at a number of sites around the world. Relatively pristine Dungeness Bay, Washington, sediments had concentrations of 0.0075 to 0.024 ppm (MacLeod), while remote areas of South America, Africa, and the Pacific atolls had 0 to 0.0098 ppm (Hites et al.). In the New England area, Buzzards Bay sediments had 0.00011 to 0.00079 ppm (Santodonato). Samples taken from the mouth of the Charles River out into Massachusetts Bay decreased from 13 to 0.019 ppm (Eadie).

Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average fluoranthene concentrations of 0.573 ppm in polluted soils, 0.0223 ppm in nonpolluted soils, and 0.0832 ppm in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether high organic content of the soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Fluoranthene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of fluoranthene. Concentrations in two samples at Thomaston Dam ranged from 1.8 to 3.0 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was too low to quantify but estimated at 0.07 ppm; at the other station, 0.50 ppm were measured (NED, 1992).

Sediment fluoranthene concentrations at Hop Brook Lake ranged from 0.24 ppm at station HB05 to 0.99 ppm at station HB14. These concentrations are orders of magnitude below Washington State sediment standards. These levels are also below the ER-M and AET, although the level at station HB14 exceeds the ER-L of 0.60 ppm. The level at station HB14 also exceeds concentrations found in clean Otter Brook Lake sediments, while being less than lightly contaminated ones at Thomaston Dam. Station HB14, a natural trap for fine-grained sediments, shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Fluoranthene levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of detectable levels in the waters of Hop Brook Lake is a further indication that fluoranthene is not a concern at this project.

(j) Fluorene. Table 36 in Appendix B summarizes standards and data for fluorene.

This PAH occurs in fossil fuels, coal tars, and is a natural product of incomplete combustion. It is biodegradable by microbes acclimated to PAHs (HSDB, 1992). Little information is available on its behavior in water or soils, but it probably partitions to organic compounds and clay particles, and is mobile in mineral soils.

No criteria have been established for fluorene for drinking water, freshwater aquatic life, or sediments. The lowest acute concentration observed to have an effect on marine aquatic life (Acute LEC) was 0.3 mg/L (IRIS, 1992). Long and Morgan (1990) report an ER-L of 0.035, an ER-M of 0.64, and an overall AET of 0.35 ppm with low confidence in the ER-L and moderate confidence in the ER-M for fluorene.

Neither EPA nor CTDEP have established criteria for fluorene in sediment. The State of Washington set sediment quality standards of 23 ppm and sediment cleanup standards of 79 ppm for fluorene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, the sediment quality standards become 4.6 and 16, and cleanup standards become 2.3 and 7.9 ppm for HB14 and HB05, respectively.

Little information is available on background concentrations of fluorene in soils or sediments. Malius et al. (1985) report detecting fluorene in sediment from three sites at Eagle Harbor, Washington. Eagle Harbor, near Puget Sound, had been receiving creosote effluents. Verschuere (1983) found 0.038 ppm fluorene in sediment from Wilderness Lake in Ontario. Kuehl et al. (1984) reported finding residues of PAHs, including fluorene, in sediments from the Buffalo River in New York.

Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average fluorene concentrations of 0.0802 ppm in polluted soils, less than detectable ( $<0.001$  ppm) in nonpolluted soils, and 0.0144 ppm in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether high organic content of the soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Fluorene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level of development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of fluorene. Concentrations in two samples at Thomaston Dam ranged from 0.095 to 0.12 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was less than the detection limit ( $<0.051$  ppm), while concentration at the other was too low to quantify but estimated at 0.028 ppm (NED, 1992).

At Hop Brook Lake, fluorene levels in sediments were too low to quantify, but were estimated at 0.022 ppm at station HB05 and 0.047 ppm at station HB14. These levels are orders of magnitude below Washington State sediment standards, and also below the ER-M, although they are close to the

ER-L and AET. Concentrations in Hop Brook sediments are within the range reported for other NED projects. In sum, fluorene levels are not a concern at this project.

(k) Indeno(1,2,3-cd)pyrene. Table 37 in Appendix B summarizes standards and data for indeno(1,2,3-cd)-pyrene.

This PAH is formed during incomplete combustion of most organic compounds. Indeno(1,2,3-cd)pyrene also naturally occurs in leaves of various types of trees. It adsorbs strongly to particulate matter, especially fine-grained and organic materials; as such, it tends to be removed from the water column by adsorption and sedimentation, and tends to be immobile in soils. It biodegrades slowly and tends to bioconcentrate in organisms which are not able to metabolize it; fish may be able to metabolize indeno(1,2,3-cd)pyrene.

Neither EPA nor CTDEP have established criteria for indeno(1,2,3-cd)pyrene in sediment. The State of Washington set sediment quality standards of 34 ppm, and sediment cleanup standards of 88 ppm for indeno(1,2,3-cd)pyrene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 6.8 and 18, and cleanup standards become 3.4 and 8.8 ppm for HB14 and HB05, respectively.

Indeno(1,2,3-cd)pyrene has been measured in sediments at other locations by a number of researchers. Marcus and Stokes (1985) found up to 0.1769 ppm in sediments from the South Carolina coast. Varanasi et al. (1985b) reported 0.009 to 0.228 ppm in sediments taken from Penobscot Bay, Maine, stations. Malins et al. (1985) examined sediments from Eagle Harbor and President Point, Washington, that had received creosote effluents; they found 0.030 to 1.2 ppm. Tan and Heit (1981) measured indeno(1,2,3-cd)pyrene concentrations from sediments at different depths in an Adirondack Lake in New York; they found 1.3 ppm in surficial sediments (0-4 cm), 0.36 ppm in sediments from a depth of 4 to 8 cm, and less than 0.002 ppm at a depth of 42 to 44 cm.

Indeno(1,2,3-cd)pyrene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition

of the sediments and not necessarily to levels of indeno-(1,2,3-cd)pyrene. Concentrations in two samples at Thomaston Dam ranged from 0.29 to 0.87 ppm (NED, 1992b). At Otter Brook Lake, concentrations at both stations were less than detectable (<0.053 ppm) (NED, 1992).

Sediment indenopyrene concentrations at Hop Brook Lake ranged from less than detectable (<0.042 ppm) at station HB05 to 0.68 ppm at station HB14. These levels are well below Washington State sediment quality standards, and within the range found in background concentrations in other parts of the country. The level at station HB14 exceeds concentrations found in clean Otter Brook Lake sediments, while being in the range in lightly contaminated ones at Thomaston Dam. Station HB14, a natural trap for fine-grained sediments, shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. Indenopyrene levels in Hop Brook Lake sediments appear to be due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is a further indication that indenopyrene is not a concern at this project.

(1) 2-Methylnaphthalene. Table 38 in Appendix B summarizes standards and data for 2-methylnaphthalene.

Also known as "beta-methylnaphthalene," this PAH has extremely low solubility in water. A derivative of coal tar and crude oil, it is widely used in organic synthesis, including vitamin K production and insecticides. It is also a combustion product of internal combustion engines and natural fires. It degrades rapidly in soils where microorganisms have adapted to PAHs, and at a lesser rate in unacclimated soils and aquatic environments (HSDB, 1992).

No criteria have been established for methylnaphthalenes for drinking water, freshwater aquatic life, or sediments.

Long and Morgan (1990) report an ER-L of 0.065, an ER-M of 0.67, and an overall AET of 0.3 ppm, with moderate confidence in the ER-L and high confidence in the ER-M.

Neither EPA nor CTDEP have established criteria for 2-methylnaphthalene in sediment. The State of Washington set sediment quality standards of 38 ppm and sediment cleanup standards of 64 ppm for 2-methylnaphthalene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 7.2 and 13, and cleanup

standards become 3.8 and 6.4 ppm for HB14 and HB05, respectively.

Limited information is available about 2-methylnaphthalene concentrations in soils or sediments at other sites. Surficial soils at a Conroe, Texas, creosote waste facility had 2-methylnaphthalene concentrations of 3.42 ppm, while soils at a depth of 24 to 25 meters had only 0.00003 ppm (Bedient et al. 1984). Sediment from the Duwamish River, Washington, had an average concentration of 0.090 ppm (Varanasi et al. 1985). Sediments from areas in coastal Washington State that had received creosote effluents were examined by Malins et al. (1985). They reported that three sites in Eagle Harbor and one at President Point, had average concentrations of 0.11, 0.17, 0.023, and <0.0035 ppm, respectively. Sediments from the Providence River, Mid-Bay, and Rhode Island Sound, Rhode Island, contained average concentrations of 0.449, 0.0115, and 0.0025 ppm, respectively (Pruell and Quinn). Sediment from George's Bank contained an average concentration of 0.00169 ppm (Phillips et al. 1987).

Concentrations of 2-methylnaphthalene were measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions, due to low level development in its watershed. On the other hand, sediments at Thomaston Dam represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of 2-methyl-naphthalene. Concentrations in two samples at Thomaston Dam were too low to quantify, but estimated at 0.020 to 0.041 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was less than detectable (<0.051 ppm), and at the other station was too low to quantify, but estimated at 0.010 ppm (NED, 1992).

Sediment 2-methylnaphthalene concentrations at Hop Brook Lake were too low to quantify, but estimated at 0.011 ppm at station HB05 and 0.024 at HB14. These levels are below the ER-L, ER-M and AET; orders of magnitude below Washington State sediment quality standards; and within the range found at other NED projects. In sum, 2-methylnaphthalene levels appear due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is further indication that this PAH is not a concern at this project.

(m) Naphthalene. Table 39 in Appendix B summarizes standards and data for naphthalene.

As reported in McKee and Wolf, this PAH is: "The most abundant single constituent of coal tar, naphthalene is a white solid with the odor of moth balls. It is soluble in water at 20 degrees centigrade to the extent of about 30 mg/L. The use of naphthalene in organic synthesis and dye manufacture is extensive, and hence it may occur in wastes from refineries, coal-tar plants, textile mills, and chemical industries." Naphthalene enters the atmosphere primarily through emissions from coal, oil, and gasoline burning operations, including internal combustion engines. Natural sources include forest fires (HSDB, 1992).

Naphthalene rapidly photodegrades in the atmosphere, and is removed from water by volatilization, photodegradation, adsorption, and biodegradation. If released to soil or sediments, it moderately adsorbs to particulate matter, but may have some mobility in groundwater. Naphthalene biodegrades in soils and sediments under aerobic conditions. Some bioconcentration can occur, but depuration and metabolism prevent this from being more than a short-term problem (HSDB, 1992).

No drinking water standards or freshwater aquatic life criteria have been established for naphthalene. Lowest observed effects concentrations for freshwater aquatic organisms are 2.3 ppm for acute exposure and 0.62 ppm for chronic exposure (IRIS, 1992).

Long and Morgan (1990) reported an ER-L of 0.34, AET of 0.50, and an ER-M of 2.1 ppm, with a moderate degree of confidence in the ER-L and high degree of confidence in the ER-M.

Neither EPA nor CTDEP have established criteria for naphthalene in sediment. The State of Washington set sediment quality standards of 99 ppm and sediment cleanup standards of 170 ppm for naphthalene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 20 and 34, and cleanup standards become 9.9 and 17 ppm for HB14 and HB05, respectively.

A number of researchers have measured naphthalene concentrations in soils or sediments. Larsen et al. (1983) detected naphthalene in 1 of 30 sediment samples from Casco Bay, Maine, at a concentration of 0.113 ppm. Teal et al. (1978) measured naphthalene concentrations in Buzzards Bay, Massachusetts, following an October 1974 oil spill. In surficial sediments (0 to 6 cm), they reported 9.2 ppm in October 1974, 0.63 ppm in May 1975, and 0.22 ppm in June 1977.



Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average naphthalene concentrations of 0.0483 ppm in polluted soils, 0.0463 ppm in nonpolluted soils, and 0.0577 ppm in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether the high organic content of the soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Naphthalene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of naphthalene. Concentrations in two samples at Thomaston Dam were too low to quantify, but estimated at 0.030 to 0.052 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was less than detectable (<0.051 ppm), and at the other, too low to quantify, but estimated at 0.014 ppm (NED, 1992).

Sediment naphthalene concentrations at Hop Brook Lake were too low to quantify, but estimated at 0.014 ppm at station HB05 and 0.030 at HB14. These levels are below the ER-L, ER-M and AET; orders of magnitude below Washington State sediment quality standards; and within the range found at other NED projects. In sum, naphthalene levels appear to be due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is further indication that this PAH is not a concern at this project.

(n) Phenanthrene. Table 40 in Appendix B summarizes standards and data for phenanthrene.

This PAH is produced by incomplete combustion; consequently, it is ubiquitous in the environment. It binds strongly to soil particles and is quickly removed from water by adsorption. Phenanthrene is biodegradable in soils (HSDB, 1992).

Criteria for drinking water or sediments have not been established. Freshwater aquatic life criteria are 30 ug/L for acute conditions and 6.3 ug/L for chronic conditions (IRIS, 1992).

Long and Morgan (1990) report an ER-L of 0.225, an ER-M of 1.38, and an overall AET of 0.26 ppm, with a moderate degree of confidence in the ER-L and ER-M for phenanthrene.

Neither EPA nor CTDEP have established criteria for phenanthrene in sediment. The State of Washington set sediment quality standards of 100 ppm and sediment cleanup standards of 480 ppm for phenanthrene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 20 and 96, and cleanup standards become 10 and 48 ppm for HB14 and HB05, respectively.

Phenanthrene has been found in surficial sediment in New York Lakes ranging from 0.015 to 0.32 ppm (Tan & Heit). Sediment samples from Boston Harbor had up to 3 ppm combined anthracene plus phenanthrene (Windsor & Hites). Measurements of New England area soil samples showed levels of combined anthracene plus phenanthrene of 0.063 ppm in Maine and 0.12 in Stoneham, Massachusetts, urban soils. Measurements of combined anthracene plus phenanthrene in soils from around the world found 0.001 to 100 ppm in Nova Scotia, 0.0048 to 0.03 ppm in Wyoming, 0.0025 to 0.067 ppm in Alaska, 0.0036 ppm in Hawaii, and 0.0003 ppm in Samoa (Hites et al. 1980).

Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average phenanthrene concentrations of 0.353 ppm in polluted soils, 0.030 ppm in nonpolluted soils, and 0.0777 ppm in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether the high organic content of the soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Phenanthrene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of phenanthrene. Concentrations in two samples at Thomaston Dam ranged from 1.2 to 1.9 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was too low to quantify, but

estimated at 0.056 ppm, while 0.39 ppm was measured at the other (NED, 1992).

Sediment phenanthrene concentrations at Hop Brook Lake ranged from 0.30 ppm at station HB05 to 0.59 ppm at station HB14. Station HB14 is a natural trap for fine-grained sediments and shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. These phenanthrene levels are below the ER-M, but exceed the ER-L of 0.225 and AET of 0.26. Hop Brook sediment phenanthrene levels are above background levels reported for many parts of the world, and in the range of Norwegian soils contaminated with total PAHs. On the other hand, they are orders of magnitude below Washington State sediment standards, in the range found in clean sediments from New York Lakes and NED's Otter Brook project in New Hampshire, and below those found at NED's Thomaston Dam in Connecticut. On the whole, phenanthrene levels in Hop Brook Lake sediments appear somewhat elevated, but due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is further indication that phenanthrene is not a concern at this project.

(o) Pyrene. Table 41 in Appendix B summarizes standards and data for pyrene.

This PAH, a product of incomplete combustion and ubiquitous in the environment, binds strongly to sediments and is quickly removed from the water column by adsorption. It bioaccumulates slightly in higher organisms, and is biodegraded by micro-organisms acclimated to PAHs (HSDB, 1992). Also known as "benzophenanthrene," this derivative of coal tar is considered insoluble in water (Merck).

No criteria have been established for pyrene for drinking water or freshwater aquatic life. The LEC for marine organisms for acute conditions was 0.3 ppm. For PAHs as a class, carcinogenicity protection, equal to a one-in-a-million lifetime increased risk, was estimated to be achieved at a level of 0.0000028 ppm for ingestion of water and organisms living in that water, while 0.00003 ppm was estimated for ingestion of organisms alone. However, it is extremely difficult to estimate criteria from carcinogenicity protection guidelines. Invariably, adopted drinking water and freshwater aquatic life criteria are orders of magnitude higher than carcinogenicity protection guidelines.

Long and Morgan (1990) report an ER-L of 0.35, an ER-M of 2.2, and an overall AET of 1.0 ppm, with a moderate degree of confidence in the ER-L and ER-M.

Neither EPA nor CTDEP have established criteria for pyrene in sediment. The State of Washington set sediment quality standards of 1,000 ppm and sediment cleanup standards of 1,400 ppm for phenanthrene (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 200 and 280, and cleanup standards become 100 and 140 ppm for HB14 and HB05, respectively.

Pyrene has been measured in soil or sediment at a number of sites in North America. Wilderness Lake in Ontario had 0.023 ppm in sediments (Verschuere), while remote Woods Lake in the Adirondacks had 0.016 to 0.93 ppm in surficial sediments (Tan and Heit). Buzzards Bay sediments had 0.12 to 0.96 ppm (Santodonato). Highest reported New England area sediment concentrations were in the Charles River at Boston where up to 13 ppm were measured (Hites et al.).

Vogt et al. (1987) investigated PAH levels around metal smelters in Norway, and found average pyrene concentrations of 0.459 ppm in polluted soils, 0.0197 ppm in nonpolluted soils, and 0.0897 ppm in bog soils. The bog soils were not directly affected by known sources of contamination, but had consistently higher levels of PAHs than nonpolluted soils. Vogt did not determine whether the high organic content of the soils accumulated PAHs from atmospheric inputs, or if PAHs were formed in the bog environment.

Pyrene was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of pyrene. Concentrations in two samples at Thomaston Dam ranged from 2.4 to 4.8 ppm (NED, 1992b). At Otter Brook Lake, concentrations were too low to quantify, but estimated at 0.094 ppm at one station, to 0.58 at the other (NED, 1992).

Sediment pyrene concentrations at Hop Brook Lake ranged from 0.64 ppm at station HB05 to 2.0 ppm at station HB14. Station HB14 is a natural trap for fine-grained sediments and shows generally higher levels of metals and other contaminants likely to attach to particulate matter, than does station HB05. These pyrene levels are below the ER-M, and the level at station HB05 is below the AET of 1.0 ppm,

but levels at both stations exceed the ER-L of 0.35 ppm. Levels at both Hop Brook stations also exceed pyrene concentrations measured in Norwegian soils polluted by total PAH, and clean sediments from Wilderness Lake, Ontario, and Otter Brook Lake in New Hampshire. On the other hand, Hop Brook sediment pyrene concentrations are orders of magnitude below Washington State sediment standards, or the maximum level measured in the polluted Charles River in Boston. Levels at Hop Brook are also below those measured at NED's Thomaston Dam project in Connecticut. On the whole, pyrene levels in Hop Brook Lake sediments appear somewhat elevated, but due to natural processes in the watershed. The absence of detectable levels in waters of Hop Brook Lake is further indication that pyrene is not a concern at this project.

## (2) Phthalate Esters

(a) Bis(2-ethylhexyl)phthalate. Table 42 in Appendix B summarizes standards and data for bis(2-ethylhexyl)phthalate.

Also known as "di(2-ethylhexyl)phthalate" and "phthalic acid, bis(2-ethylhexyl) ester," it is a common plasticizer especially in the manufacture of PVC. It is released to the environment during manufacture and incineration of these plastics, as well as leaching from plastic materials. It has an affinity for particles, is biodegradable, and bioconcentrates in higher organisms (HSDB, 1992). Bis(2-ethylhexyl) phthalate is also a common laboratory contaminant.

Criteria for bis(2-ethylhexyl)phthalate in drinking water have not been established; however, a maximum contaminant level goal of 4 ug/L has been proposed. Criteria to protect freshwater aquatic life have been set at 0.40 mg/L for acute conditions and 0.36 for chronic conditions (IRIS, 1992).

Neither EPA nor CTDEP have established criteria for bis(2-ethylhexyl)phthalate in sediment. The State of Washington set sediment quality standards of 47 ppm and sediment cleanup standards of 78 ppm bis(2-ethylhexyl)-phthalate (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 9.4 and 1.6, and cleanup standards become 4.7 and 7.8 ppm for HB14 and HB05, respectively.

Sediment data for bis(2-ethylhexyl)phthalate is limited; however, a sampling of nine coastal sites at

Portland, Maine, found detectable levels at all locations, with a range of 0.06 to 7.8 ppm (Ray et al.).

Bis(2-ethylhexyl)phthalate was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of bis(2-ethylhexyl)-phthalate. Concentrations in two samples at Thomaston Dam ranged from 0.14 to 0.98 ppm (NED, 1992b). At Otter Brook Lake, the range was from less than detectable (<0.053) to 0.10 ppm (NED, 1992).

Bis(2-ethylhexyl)phthalate was measured at 0.41 ppm in sediment from station HB05, and 0.52 ppm in sediment from station HB14. These levels are very low compared to State of Washington sediment standards, and within the range reported for background conditions and other NED projects. Therefore, levels of bis(2-ethylhexyl)-phthalate are not a concern at Hop Brook Lake.

(b) Diethylphthalate. Table 43 in Appendix B summarizes standards and data for diethylphthalate.

Also known as "ethyl phthalate" and "phthalic acid, diethyl ester," it is an insoluble, oily liquid (Merck). It has many uses including a solvent in manufacture of varnishes, fixative for perfumes, and denaturing of alcohol; however, its primary use is as a plasticizer. As such, it is ubiquitous in the environment being released during manufacture and incineration of plastics. It is also released from plastics directly. Plastic waste is the main source of diethyl phthalate into soil, water, and air (HSDB, 1992). Through volatilization and leaching phthalates, are also common laboratory contaminants.

Diethylphthalate adsorbs moderately to particulates and has limited mobility in soil. It biodegrades readily and does not bioconcentrate because it is readily metabolized (HSDB, 1992).

Neither EPA nor CTDEP have established criteria for diethylphthalate in sediment. The State of Washington set sediment quality standards of 61 ppm and sediment cleanup standards of 110 ppm diethylphthalate (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent

at station HB14 and 10 percent at station HB05, sediment quality standards become 12 and 22, and cleanup standards become 6.1 and 11 ppm for HB14 and HB05, respectively.

Concentrations measured at other sites include 0.013 to 0.049 ppm in surficial sediments in Chesapeake Bay (Peterson and Freeman, 1982), 0.011 to 0.044 ppm in sediments from the Chester River in Maryland (Peterson and Freeman, 1984), 0.025 to 0.065 ppm in sediments from Lake Pontchartrain, Louisiana (McFall et al. 1985), and less than 0.002 to 0.009 ppm in sediments from San Luis Pass, Texas (Murray et al. 1981).

Diethylphthalate was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of diethylphthalate. Concentrations in two samples at Thomaston Dam ranged from 0.088 to 0.091 ppm (NED, 1992b). At Otter Brook Lake, the concentration at one station was below the detection limit (<0.053), while 0.12 ppm were recorded for the second station. However, the method blank for that analysis had a reported 0.076 ppm (NED, 1992); consequently, it is questionable whether the 0.12 ppm measurement represented an actual finding of diethylphthalate.

Levels in sediments at Hop Brook Lake ranged from 0.22 ppm at station HB05 to 0.29 ppm at station HB14. These levels are fairly high compared to background levels and concentrations measured at other NED projects. However, they are very low compared to Washington State sediment standards; for this reason, and due to its biodegradability, levels of diethylphthalate are not a concern at Hop Brook Lake.

(c) Di-n-butylphthalate. Table 44 in Appendix B summarizes standards and data for Di-n-butylphthalate.

Also known as "dibutyl phthalate," "n-butyl phthalate," and "phthalic acid, dibutyl ester," it is an ubiquitous pollutant in the environment due to its widespread use as a plasticizer. It is released in vapor emissions during manufacturing and incineration of plastics, and from migration from plastics containing it. Di-n-butylphthalate absorbs moderately to sediments, is readily biodegradable,

and does not bioconcentrate because it is readily metabolized (HSDB, 1992). An oily liquid, it is soluble in water at about 400 ppm (Merck).

Neither EPA nor CTDEP have established criteria for di-n-butylphthalate in sediment. The State of Washington set sediment quality standards of 220 ppm, and sediment cleanup standards of 1,700 ppm for di-n-butylphthalate (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 44 and 340, and cleanup standards become 22 and 170 ppm for HB14 and HB05, respectively.

Di-n-butylphthalate has been measured in soil and sediments at a number of locations in the United States. Surficial sediments in Chesapeake Bay had 27 and 89 ppb, with the site closest to Baltimore Harbor having the higher concentration (Peterson and Freeman, 1982). Eight samples of Portland, Maine, sediment had 40 to 280 ppb, with a mean of 160 ppb (Ray et al. 1983). Giam found di-n-butylphthalate concentrations of 0 to 52.1 ppb, 13 ppb average in the Mississippi delta; 0 to 15.3 ppb, 7.6 ppb average in the Gulf coast; and 1.6 to 5.6 ppb, 3.4 ppb average in the open Gulf (Giam et al. 1978). Mayer reported 100 ppb in sediments in Black Bay of Lake Superior (Mayer et al. 1972). Lake Erie sediments from 18 locations from the Detroit River to Stony Point had 3 to 6 ppb, and Lake Huron at the Saginaw River had 290 ppb (Konasewich et al. 1978). Surficial sediment from the Delaware River estuary had 4.5 ppb (Hochreiter, 1982).

Di-n-butylphthalate was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of di-n-butylphthalate. Concentrations in two samples at Thomaston Dam ranged from 0.11 to 0.14 ppm (NED, 1992b). At Otter Brook Lake, measured concentrations ranged from 0.11 to 0.14 ppm. However, the method blank for that analysis had a reported 0.1 ppm (NED, 1992); consequently, it is questionable whether there was an actual finding of di-n-butylphthalate.

Measured levels of di-n-butylphthalate in sediments at Hop Brook Lake ranged from 0.32 ppm at station HB05



to 0.60 ppm at station HB14; 0.9 ppm were reported in the method blank. Di-n-butylphthalate is a common laboratory contaminant due to its widespread use as a plasticizer. Levels reported for Hop Brook Lake sediments are somewhat elevated compared to other NED projects and background concentrations. However, finding of di-n-butylphthalate in the method blanks for Hop Brook and Otter Brook Lake analyses makes it highly likely that actual levels are lower. Because levels reported for Hop Brook Lake are orders of magnitude below Washington State sediment standards, di-n-butylphthalate levels are not a concern at this project.

(d) Di-n-octyl phthalate. Table 45 in Appendix B summarizes standards and data for Di-n-octyl phthalate.

Chemical name "phthalic acid, dioctyl ester," di-n-octyl phthalate is used as a plasticizer especially in the manufacture of polyvinyl chloride (PVC). Naturally rigid and hard, PVC becomes softer and more flexible with the addition of plasticizers. The primary environmental source is in industrial wastewater from processes using plasticizers. In streams it absorbs strongly to sediments (HSDB, 1992). Phthalates are also common laboratory contaminants. No drinking water standards have been established for di-n-octyl phthalate, or most phthalates for that matter. A maximum contaminant level (MCL) of 4 ug/L has been proposed for bis(2-ethylhexyl) phthalate which is a similar compound. No criteria to protect freshwater aquatic life are established or proposed for di-n-octyl phthalate or bis(2-ethylhexyl) phthalate; however, the lowest reported toxic concentrations for bis(2-ethylhexyl) phthalate in freshwater is 94 ug/L as an acute condition and 3 ug/L as a chronic condition.

Neither EPA nor CTDEP have established criteria for di-n-octyl phthalate in sediment. The State of Washington set sediment quality standards of 58 ppm and sediment cleanup standards of 4,500 ppm for di-n-octyl phthalate (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 12 and 900, and cleanup standards become 5.8 and 450 ppm for HB14 and HB05, respectively.

Little information is available on levels of di-n-octyl phthalate in sediments or soils at other locations. An unspecified U.S.A. river had 1.5 to 25 ppm in sediments below a specialty chemical company (Jungclaus et al. 1978). Measurements at two sites below a plasticizer manufacturing plant in Morgan Creek, a tributary of Chester River which flows into Chesapeake Bay, found <0.005 ppm to 0.062 ppm (Peterson and Freeman, 1984).

Di-n-octyl phthalate was measured in sediments at two other NED projects: Thomaston Dam in Connecticut and Otter Brook Lake in New Hampshire. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of di-n-octyl phthalate. Measurements in two samples at Otter Brook Lake gave reported levels of 0.34 ppm; however, 0.15 ppm were reported for the method blank, indicating the reported sediment levels were probably due to sample contamination (NED, 1992). At Thomaston Dam, measured concentrations ranged from less than detectable (<0.048) to 0.36 ppm (NED, 1992b). No di-n-octyl phthalate was reported in the blank (<0.05 ppm).

At Hop Brook Lake, reported sediment di-n-octyl phthalate concentrations ranged from less than detectable (<0.042 ppm) at station HB05 to 0.26 ppm at station HB14. However, the measurement of 0.27 ppm in the field blank indicates detectable results were probably due to sample contamination. In any case, the maximum reported level in orders of magnitude below Washington State sediment standards, and di-n-octyl phthalate is not a concern at this project.

(3) Dibenzofuran. Table 46 in Appendix B summarizes standards and data for dibenzofuran.

Dibenzofuran is a product of incomplete combustion of coal, refuse, and diesel fuel. If released to water, dibenzofuran attaches strongly to particulate matter and is removed by sedimentation or adsorption. Because of its affinity for fine-grained and organic materials, dibenzofuran has little mobility in soils. It biodegrades readily in the presence of aerobic conditions and adapted microorganisms (HSDB, 1992).

No drinking water standards or freshwater aquatic life criteria have been established for dibenzofuran.

Neither EPA nor CTDEP have established criteria for dibenzofuran in sediment. The State of Washington set sediment quality standards of 15 ppm and sediment cleanup standards of 58 ppm dibenzofuran (Ginn and Pastorok, 1992). Assuming a sediment TOC concentration of 20 percent at station HB14 and 10 percent at station HB05, sediment quality standards become 3.0 and 12, and cleanup standards become 1.5 and 5.8 ppm for HB14 and HB05, respectively.

A few researchers have measured dibenzofuran levels in sediments. Bjoerseth et al. (1979) detected dibenzofuran levels of 0.0067 to 0.919 ppm in sediments from a Norwegian fjord receiving industrial effluents. McFall et al. (1985) collected sediments from Lake Pontchartrain in Louisiana and found concentrations of 0.0019 ppm. Malins et al. (1985) measured 0.031 to 3.6 ppm dibenzofuran in sediments from Eagle Harbor (near Puget Sound), which had been receiving creosote effluents. Phillips et al. (1987) found 0.00094 ppm in sediments from Georges Bank, off Martha's Vineyard.

Other NED projects where dibenzofuran was measured in sediments include Otter Brook Lake in New Hampshire and Thomaston Dam in Connecticut. Otter Brook's sediments are typical of clean background conditions due to low level development in its watershed. Sediments at Thomaston Dam, on the other hand, represent lightly contaminated conditions due to upstream discharges and urban development in its watershed. "Lightly contaminated" refers to the overall condition of sediments and not necessarily to levels of acenaphthylene. Two samples were examined at Otter Brook Lake, and dibenzofuran was less than the detection limit of 0.051 ppm in both samples (NED, 1992b). At Thomaston Dam, dibenzofuran levels in one sample were less than the detection limit (<0.050 ppm), and the other sample was too low to quantify but estimated at 0.033 ppm (NED, 1992).

Dibenzofuran at Hop Brook Lake was detected in sediment samples at levels too low to quantify, and was estimated at 0.022 ppm at station HB14 and 0.0095 ppm at station HB05. These levels were actually below the detection level of 0.033 ppm in the method blank. Dr Mark Anthony, formerly of ORD, believed if a compound were not measured above 10 times the detection limit, it was not a confirmed finding. Because estimated levels were below the detection limit in the blank, it is questionable whether dibenzofuran was actually detected.

Dibenzofuran levels at Hop Brook Lake are low, within the range detected at other NED projects, indicative of natural background levels in the watershed, and not a cause for concern.

## 8. DISCUSSION

a. PCBs. No PCBs were found in water and only low levels were found in sediments. Measured PCB concentrations in Hop Brook soils are typical of background concentrations. Such levels may be high enough to have effects on organisms,

but are not toxic and are well below levels requiring cleanup or remediation.

b. Dioxins and Furans. No furans were found in sediments or water. No dioxins were found in water samples, and only low levels were found in sediments. Dioxin levels at Hop Brook Lake appear to be typical of urban soils. Although the OCDD level was somewhat above mean levels for uncontaminated soils, it is within the range observed for urban U.S.A. soils without an obvious source of contamination. Hop Brook Lake is surrounded by urbanized areas and is a sort of urban park. Also, station HB14 is a trap for fine sediment particles, and is the location that would be expected to have the highest concentrations of dioxins and furans. At Birch Hill Dam, a maximum of 11 ppb OCDD were found in sediments; fish from that area had elevated levels of dioxin, but did not exceed FDA advisories (Penko, 1992). Consequently, it is unlikely fish at Hop Brook Lake would be unsafe for human consumption. Dioxin levels at Hop Brook Lake should have a high priority for repeat monitoring, but are not otherwise a concern.

c. Pesticides. No detectable levels of pesticides were found in water samples, but DDT and its metabolites (DDE and DDD) were found in sediment samples. Levels detected were somewhat elevated, probably due to agricultural activities in the watershed. However, concentrations were not so high as to indicate unusual or harmful conditions.

d. Metals in Soil. Most metals analyzed were found in detectable concentrations in soils which is as expected. Aluminum, iron, and magnesium were found in highest concentrations, a condition typical of New England soils. Levels of all metals were higher at lake station HB14 than river station HB05 due to HB14's action as a trap for fine-grained sediment. Metals in water tend to bind to particulate matter, especially organic matter, making the finding of higher metal levels at HB14 unsurprising. While levels of metals at HB05 were low and indicative of unpolluted conditions, levels of barium, chromium, copper, iron, lead, nickel, silver, and zinc at station HB14 were in the range of moderately polluted to polluted sediments by some criteria. However, elevated levels of these metals were more due to concentrating action of station HB14 as a sediment trap than an indication of heavy metal contamination in the watershed.

e. Metals in Water. Metals analyses in water at Hop Brook Lake found generally low to nondetectable levels. No metals were found in levels which were a threat to humans

or aquatic life at Hop Brook Lake. Levels of total aluminum, antimony, and copper levels exceeded criteria for dissolved fractions of these metals. However, it is unlikely that significant portions of these metals were in soluble forms. Iron and manganese levels exceeded secondary drinking water criteria which are not a threat to public health, but are set to protect public welfare; however, Hop Brook is not used for public water supply, and iron and manganese levels were not a threat to aquatic life.

f. Volatile Organic Compounds. The only detectable levels of volatile organics found in water or sediments were acetone, methylene chloride, and 2-butanone. None of these were in concentrations high enough to be of concern. Acetone and methylene chloride are common laboratory artifacts and were both detected in the blanks; consequently, measured levels were likely due to sample contamination.

A detectable concentration of 2-butanone, better known as methy ethyl ketone (MEK) was reported in the sediment sample, at a concentration greater than the upper calibration limit of 0.47 ppm. The most likely source of MEK at station HB14 is the biological degradation of organic material. This MEK should be reduced over time by dissolution and volatilization, and biological degradation. It is unlikely that MEK is a problem at this project.

g. Semivolatile Organic Compounds--Water. The only semivolatile organic compound detected in water samples from Hop Brook Lake was di-n-octyl phthalate. This compound is a plasticizer and common laboratory contaminant, and was also found in the blank; consequently, measured levels were likely due to sample contamination.

h. Semivolatile Organic Compounds--Sediment. A number of semivolatile organic compounds were found in Hop Brook Lake sediments, but none in concentrations threatening harm to recreational users or aquatic life. These compounds were either PAHs, which are ubiquitous products of incomplete combustion, or phalate esters, which are plasticizers and found everywhere in the environment. The only exception was dibenzofuran, which was found in low concentrations indicative of natural background levels in the watershed.

(1) PAHs. Measurable quantities of 16 polynuclear aromatic hydrocarbons were reported for Hop Brook sediments. Very low concentrations of acenaphthene, acenaphthylene, anthracene, and fluorene were found. Low concentrations of benzo(b)- and benzo(k)fluoranthene, benzo(g,h,i)perylene, 2-methylnaphthalene, and naphthalene were measured. Levels

of benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene were in the range of lightly contaminated conditions. All PAHs were the result of normal activities in the watershed. None were in concentrations which would harm aquatic life forms likely to live in Hop Brook Lake, or recreational users of the lake.

(2) Plasticizers. After the incomplete combustion products, the most common semivolatile organic compounds detected were plasticizers. Two of these, di-n-butylphthalate and di-n-octyl phthalate, were also measured in the blank, indicating sample contamination as the likely source. Other plasticizers detected were bis(2ethylhexyl)-phthalate and diethylphthalate. These were found at levels typical of lightly contaminated conditions; however, they were not a threat to aquatic life forms likely to live in Hop Brook Lake, or recreational users of the lake. Source of these compounds was likely normal activities in the watershed.

(3) Others. Dibenzofuran was the only detected semivolatile organic compound which did not fall into the above categories. It was found in very low concentrations, which were not a threat to aquatic life forms or recreational users of the lake. Source of this compound was likely natural conditions in the watershed.

## 9. CONCLUSIONS

Levels of EPA priority pollutants at Hop Brook Lake are generally low, although a few semivolatile organic compounds are present in sediments at concentrations typical of lightly contaminated conditions. Levels of these compounds are not a threat to aquatic life forms likely to live in Hop Brook Lake, or recreational users of the lake. Sources of these compounds were likely normal activities in the watershed.

Hop Brook Lake is a sink for fine-grained particulate matter, because metals and organic compounds tend to bind to such compounds; somewhat elevated levels are found in deeper sediments. Virtually all metals and organic compounds were found in higher concentrations at lake station HB14, than discharge station HB05.

Results from this priority pollutant scan at Hop Brook Lake can be used as a reference when evaluating results from other studies.

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APPENDIX A

HOP BROOK LAKE  
PRIORITY POLLUTANT SCAN DATA

Note: A complete listing of the data including quality control and quality assurance results are contained in "Analytical Data Report, Hop Brook Lake, CT," February 24, 1992, prepared by the U.S. Army Corps of Engineers, New England Division, Environmental Laboratory, Hubbardston, Massachusetts 01452.

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON

02/13/92  
07:04

HOP BROOK LAKE, CT (9/30/91)

EPA METHOD 8280: POLYCHLORINATED DIOXINS/FURANS  
ng/g

*****				
*		14972	METHOD	*
*	PARAMETER	HB-14	BLANK	*
*		SEDIMENT	SEDIMENT	*
*****				
*	Tetrachlorodibenzodioxins	< 0.027	< 0.0026	*
*	Pentachlorodibenzodioxins	< 0.070	< 0.017	*
*	Hexachlorodibenzodioxins	< 0.068	< 0.020	*
*	Heptachlorodibenzodioxins	< 0.15	< 0.0060	*
*	Octachlorodibenzodioxins	2.9	< 0.042	*
*****				
*	Tetrachlorodibenzofurans	< 0.015	< 0.0015	*
*	Pentachlorodibenzofurans	< 0.021	< 0.0041	*
*	Hexachlorodibenzofurans	< 0.049	< 0.0090	*
*	Heptachlorodibenzofurans	< 0.10	< 0.011	*
*	Octachlorodibenzofurans	< 0.63	< 0.034	*
*****				
*	Internal Standard Recovery (%)			*
*	(40-140)			*
*****				
*	13C-2,3,7,8-TCDF	44	82	*
*	13C-2,3,7,8-TCDD	51	85	*
*	13C-1,2,3,7,8-PeCDD	51	73	*
*	13C-1,2,3,6,7,8-HxCDD	50	72	*
*	13C-1,2,3,4,6,7,8-HpCDD	41	54	*
*	13C-OCDD	28	39	*
*****				

SAMPLE DATE:	9/30/91	
DATE PREPARED:	1/29/92	1/29/92
DATE ANALYZED:	2/3/92	2/3/92

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON

02/24/92

07:54

HOP BROOK LAKE, CT (9/30/91)

PCBs (ppb)

```
*****
*          *          14971      14973      METHOD
*  PARAMETER  *          HB-15      HB05      BLANK
*          *          *          *          *
*          *          WATER      WATER      WATER
*****
* Total PCBs      *      <    0.048    <    0.050    <    0.050
*****
* Surrogate Recovery ( % ) *
*          *          *          *          *
*   TCMX      (17-125) *          39          54          46
*          *          *          *          *
*****
```

SAMPLE DATE:	9/30/91	9/30/91	
DATE RECEIVED:	9/30/91	9/30/91	
DATE EXTRACTED:	10/7/91	10/7/91	10/7/91
DATE ANALYZED:	10/28/91	10/28/91	10/28/91

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON

02/24/92  
07:54

HOP BROOK LAKE, CT (9/30/91)

PCBs (ppm)

```
*****
*          *          14972      14974      METHOD
*  PARAMETER  *          HB-14      HB05      BLANK
*          *
*          *          SEDIMENT      SEDIMENT      SEDIMENT
*****
*  Total PCBs  *          0.090      0.020      < 0.0025
*****
*  Surrogate Recovery ( % ) *
*          *
*  TCMX      (45-140) *          78          95          68
*          *
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SAMPLE DATE:      9/30/91      9/30/91
DATE RECEIVED:    9/30/91      9/30/91
DATE EXTRACTED:   10/9/91      10/9/91      10/9/91
DATE ANALYZED:    11/1/91      10/28/91      10/28/91
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*****				
	14971	14974	METHOD	
PARAMETER	HB-14	HB05	BLANK	
	WATER	WATER	WATER	
*****				
* Alpha-BHC	< 0.038	< 0.040	<	0.040
* Gamma-BHC (Lindane)	< 0.038	< 0.040	<	0.040
* Beta-BHC	< 0.038	< 0.040	<	0.040
* Heptachlor	< 0.038	< 0.040	<	0.040
* Delta-BHC	< 0.038	< 0.040	<	0.040
* Aldrin	< 0.038	< 0.040	<	0.040
* Heptachlor epoxide	< 0.038	< 0.040	<	0.040
* Endosulfan I	< 0.038	< 0.040	<	0.040
* 4,4'-DDE	< 0.076	< 0.080	<	0.080
* Dieldrin	< 0.076	< 0.080	<	0.080
* Endrin	< 0.076	< 0.080	<	0.080
* 4,4'-DDD	< 0.076	< 0.080	<	0.080
* Endosulfan II	< 0.076	< 0.080	<	0.080
* 4,4'-DDT	< 0.076	< 0.080	<	0.080
* Endrin aldehyde	< 0.076	< 0.080	<	0.080
* Endosulfan sulfate	< 0.076	< 0.080	<	0.080
* Methoxychlor	< 0.38	< 0.40	<	0.40
*****				
* Surrogate Recovery ( % )				
* Dibutyl chlorendate	78	79		71
* TCMX	35	48		42
*****				

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

=====

PRODUCED ON 02/24/92  
07:44

HOPBROOK LAKE, CT (9/30/91)

METHOD 8080: PESTICIDES - SEDIMENT (ug/kg)

*****					
*		*	14972	14974	METHOD
*	PARAMETER	*	HB-14	HB05	BLANK
*		*	SEDIMENT	SEDIMENT	SEDIMENT
*****					
*	Alpha-BHC	*	< 7.5	< 3.2	< 2.0
*	Gamma-BHC (Lindane)	*	< 7.5	< 3.2	< 2.0
*	Beta-BHC	*	< 7.5	< 3.2	< 2.0
*	Heptachlor	*	< 7.5	< 3.2	< 2.0
*	Delta-BHC	*	< 7.5	< 3.2	< 2.0
*	Aldrin	*	< 7.5	< 3.2	< 2.0
*	Heptachlor epoxide	*	< 7.5	< 3.2	< 2.0
*	Endosulfan I	*	< 7.5	< 3.2	< 2.0
*	4,4'-DDE	*	15	< 6.4	< 4.0
*	Dieldrin	*	< 15	< 6.4	< 4.0
*	Endrin	*	< 15	< 6.4	< 4.0
*	4,4'-DDD	*	17	< 6.4	< 4.0
*	Endosulfan II	*	< 15	< 6.4	< 4.0
*	4,4'-DDT	*	26	12	< 4.0
*	Endrin aldehyde	*	< 15	< 6.4	< 4.0
*	Endosulfan sulfate	*	< 15	< 6.4	< 4.0
*	Methoxychlor	*	< 75	< 32	< 20
*****					
*	Surrogate Recovery ( % )				
*	Dibutyl chlorendate		62	*	76
*	TCMX		89	108	62
*****					

SAMPLE DATE:	9/30/91	9/30/91	
DATE EXTRACTED:	10/10/91	10/10/91	10/10/91
DATE ANALYZED:	11/15/91	11/13/91	11/9/91

NOTE:

\* - Matrix effect.

U. S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

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PRODUCED ON 02/24/92  
07:45

HOP BROOK LAKE, CT (9/30/91)

TRACE METAL RESULTS - WATER (ppm)

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*****
*          *          14971          14973          METHOD          *
*    PARAMETER    *          HB-14          HB05          BLANK          *
*          *          *          *          *          *          *
*****
* Aluminum        *          0.25          0.26          < 0.0060          *
* Antimony        *          J 0.081          J 0.11          < 0.0090          *
* Arsenic         *          < 0.0050          < 0.0050          < 0.0050          *
* Barium          *          0.020          0.021          < 0.0020          *
* Beryllium       *          < 0.0040          < 0.0040          < 0.0040          *
* Cadmium         *          < 0.0050          < 0.0050          < 0.0050          *
* Calcium         *          8.8          9.0          < 0.0010          *
* Chromium        *          < 0.015          < 0.015          < 0.015          *
* Cobalt          *          J 0.018          J 0.021          < 0.0020          *
* Copper          *          J 0.0092          J 0.0010          < 0.0060          *
* Iron            *          0.60          0.57          < 0.013          *
* Lead            *          < 0.0030          < 0.0030          < 0.0030          *
* Manganese       *          0.17          0.10          < 0.0050          *
* Magnesium       *          2.7          2.7          < 0.0020          *
* Mercury         *          < 0.00030          < 0.00030          < 0.00030          *
* Nickel          *          < 0.035          < 0.035          < 0.035          *
* Potassium       *          2.4          2.6          < 0.085          *
* Selenium        *          < 0.0050          < 0.0050          < 0.0050          *
* Silver          *          < 0.013          < 0.013          < 0.013          *
* Sodium          *          12          13          < 0.025          *
* Thallium        *          < 0.0050          < 0.0050          < 0.0050          *
* Vanadium        *          < 0.0040          < 0.0040          < 0.0040          *
* Zinc            *          < 0.0050          < 0.0050          < 0.0050          *
*****
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SAMPLE DATE:          9/30/91          9/30/91
DATE ANALYZED:       10/21/91          10/21/91          10/21/91

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NOTES:

Mercury was digested on 10/16/91 and analyzed on 10/17/91.

J - Estimated value; analyte detected < the practical quantitation limit.

U. S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

=====

PRODUCED ON 02/24/92  
07:45

HOP BROOK LAKE, CT (9/30/91)

TRACE METAL RESULTS - SEDIMENT (ppm)

*****					
*	*	14972	14974	METHOD	*
PARAMETER	*	HB-14	HB05	BLANK	*
*****					
* Aluminum	*	34000	3500	< 0.60	*
* Antimony	*	J 68	J 3.1	< 0.90	*
* Arsenic	*	2.2	0.88	< 0.50	*
* Barium	*	210	18	< 0.20	*
* Beryllium	*	1.8	0.17	< 0.40	*
* Cadmium	*	3.4	< 0.50	< 0.50	*
* Calcium	*	3200	1500	< 0.50	*
* Chromium	*	48	J 4.6	< 1.5	*
* Cobalt	*	J 20	J 3.0	< 0.20	*
* Copper	*	39	13	< 0.60	*
* Iron	*	44000	9800	< 1.3	*
* Lead	*	58	16	< 0.30	*
* Manganese	*	810	95	< 0.50	*
* Magnesium	*	8700	1700	< 14	*
* Mercury	*	0.12	< 0.030	< 0.030	*
* Nickel	*	J 31	J 5.1	< 3.5	*
* Potassium	*	6100	750	< 8.5	*
* Selenium	*	< 0.50	< 0.50	< 0.50	*
* Silver	*	10	< 1.3	< 1.3	*
* Sodium	*	250	96	< 2.2	*
* Thallium	*	< 0.50	< 0.50	< 0.50	*
* Vanadium	*	< 0.40	< 0.40	< 0.40	*
* Zinc	*	280	33	< 0.50	*
*****					

SAMPLE DATE:	9/30/91	9/30/91	
DATE ANALYZED:	10/21/91	10/21/91	10/21/91

NOTES:

Mercury was digested on 10/16/91 and analyzed on 10/17/91.

J - Estimated value; analyte detected < the practical quantitation limit.

*****								
	*		14970		14971		14973	METHOD
	*		TB		HB-14		HB05	BLANK
	*		W		W		W	W
*****								
* Chloromethane	*	<	5.0	<	5.0	<	5.0	< 5.0
* Vinyl chloride	*	<	5.0	<	5.0	<	5.0	< 5.0
* Bromomethane	*	<	5.0	<	5.0	<	5.0	< 5.0
* Chloroethane	*	<	5.0	<	5.0	<	5.0	< 5.0
* 1,1-Dichloroethene	*	<	2.0	<	2.0	<	2.0	< 2.0
* Acetone	*	J	51	J	30	J	36	J 25
* Carbon disulfide	*	<	2.0	<	2.0	<	2.0	< 2.0
* Methylene chloride	*		19		11		11	12
* trans-1,2-Dichloroethene	*	<	2.0	<	2.0	<	2.0	< 2.0
* 1,1-Dichloroethane	*	<	2.0	<	2.0	<	2.0	< 2.0
* cis-1,2-Dichloroethene	*	<	2.0	<	2.0	<	2.0	< 2.0
* 2-Butanone	*	<	100	<	100	<	100	< 100
* Chloroform	*	<	2.0	<	2.0	<	2.0	< 2.0
* 1,1,1-Trichloroethane	*	<	2.0	<	2.0	<	2.0	< 2.0
* Carbon tetrachloride	*	<	2.0	<	2.0	<	2.0	< 2.0
* Benzene	*	<	2.0	<	2.0	<	2.0	< 2.0
* 1,2-Dichloroethane	*	<	2.0	<	2.0	<	2.0	< 2.0
* Trichloroethene	*	<	2.0	<	2.0	<	2.0	< 2.0
* 1,2-Dichloropropane	*	<	2.0	<	2.0	<	2.0	< 2.0
* Bromodichloromethane	*	<	2.0	<	2.0	<	2.0	< 2.0
* 4-Methyl-2-pentanone	*	<	50	<	50	<	50	< 50
* cis-1,3-Dichloropropene	*	<	2.0	<	2.0	<	2.0	< 2.0
* Toluene	*	<	2.0	<	2.0	<	2.0	< 2.0
*****								

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON

02/24/92  
07:47

HOP BROOK LAKE, CT (9/30/91)

METHOD 8240: VOLATILE ORGANICS - WATER (ug/L)

*****									
		14970	14971	14973	METHOD				
	PARAMETER	TB	HB-14	HB05	BLANK				
		W	W	W	W				
*****									
*	trans-1,3-Dichloropropene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	1,1,2-Trichloroethane	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	Tetrachloroethene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	2-Hexanone	< 50	< 50	< 50	< 50	< 50			*
*	Dibromochloromethane	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	Chlorobenzene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	Ethylbenzene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	m/p Xylene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	O-Xylene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	Styrene	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	Bromoform	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*	1,1,2,2-Tetrachloroethane	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0			*
*****									
*	Surrogate Recovery (%)								*
*	1,2-Dichloroethane D4 (90-125)	109	101	109	96				*
*	Toluene D8 (80-120)	89	86	85	76				*
*	4-Bromofluorobenzene (70-105)	80	73	56	79				*
*****									
*	DILUTION FACTOR	1.0	1.0	1.0	1.0				*
*****									

SAMPLE DATE:	9/30/91	9/30/91	9/30/91	
DATE ANALYZED:	10/1/91	10/1/91	10/1/91	10/1/91

J - Estimated value; analyte detected at < the Practical Quantitation Limit.

*****						
*	*	14972	14974	METHOD	*	*
*	PARAMETER	HB-14	HB05	BLANK	*	*
*	*	S	S	S	*	*
*****						
* Chloromethane	*	< 10	< 4.4	< 5.0	*	*
* Vinyl chloride	*	< 10	< 4.4	< 5.0	*	*
* Bromomethane	*	< 10	< 4.4	< 5.0	*	*
* Chloroethane	*	< 10	< 4.4	< 5.0	*	*
* 1,1-Dichloroethene	*	< 4.1	< 1.8	< 2.0	*	*
* Acetone ***	*	6477	J 53	J 47	*	*
* Carbon disulfide	*	< 4.1	< 1.8	< 2.0	*	*
* Methylene chloride	*	9.7	5.1	19	*	*
* trans-1,2-Dichloroethene	*	< 4.1	< 1.8	< 2.0	*	*
* 1,1-Dichloroethane	*	< 4.1	< 1.8	< 2.0	*	*
* cis-1,2-Dichloroethene	*	< 4.1	< 1.8	< 2.0	*	*
* 2-Butanone	*	U 472	< 89	< 100	*	*
* Chloroform	*	< 4.1	< 1.8	< 2.0	*	*
* 1,1,1-Trichloroethane	*	< 4.1	< 1.8	< 2.0	*	*
* Carbon tetrachloride	*	< 4.1	< 1.8	< 2.0	*	*
* Benzene	*	< 4.1	< 1.8	< 2.0	*	*
* 1,2-Dichloroethane	*	< 4.1	< 1.8	< 2.0	*	*
* Trichloroethene	*	< 4.1	< 1.8	< 2.0	*	*
* 1,2-Dichloropropane	*	< 4.1	< 1.8	< 2.0	*	*
* Bromodichloromethane	*	< 4.1	< 1.8	< 2.0	*	*
* 4-Methyl-2-pentanone	*	< 103	< 44	< 50	*	*
* cis-1,3-Dichloropropene	*	< 4.1	< 1.8	< 2.0	*	*
* Toluene	*	< 4.1	< 1.8	< 2.0	*	*
*****						

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON

02/24/92  
07:58

HOP BROOK LAKE, CT (9/30/91)

METHOD 8240: VOLATILE ORGANICS - SEDIMENT (ug/kg)

*****					
*		14972	14974	METHOD	*
*	PARAMETER	HB-14	HB05	BLANK	*
*		S	S	S	*
*****					
*	trans-1,3-Dichloropropene	< 4.1	< 1.8	< 2.0	*
*	1,1,2-Trichloroethane	< 4.1	< 1.8	< 2.0	*
*	Tetrachloroethene	< 4.1	< 1.8	< 2.0	*
*	2-Hexanone	< 103	< 44	< 50	*
*	Dibromochloromethane	< 4.1	< 1.8	< 2.0	*
*	Chlorobenzene	< 4.1	< 1.8	< 2.0	*
*	Ethylbenzene	< 4.1	< 1.8	< 2.0	*
*	m/p Xylene	< 4.1	< 1.8	< 2.0	*
*	O-Xylene	< 4.1	< 1.8	< 2.0	*
*	Styrene	< 4.1	< 1.8	< 2.0	*
*	Bromoform	< 4.1	< 1.8	< 2.0	*
*	1,1,2,2-Tetrachloroethane	< 4.1	< 1.8	< 2.0	*
*****					
*	Surrogate Recovery (%)				*
*	1,2-Dichloroethane D4 (70-121)	108	114	115	*
*	Toluene D8 (84-138)	94	92	96	*
*	4-Bromofluorobenzene (59-113)	75	81	86	*
*****					
*	DILUTION FACTOR	2.1	0.89	1.0	*
*****					
*	*** - DILUTION FACTOR FOR				*
*	THESE SPECIFIC ANALYTES	277	1	1	*
*****					
	SAMPLE DATE:	9/30/91	9/30/91		
	DATE ANALYZED:	10/2/91	10/1/91	10/1/91	

J - Estimated value; analyte detected at < the Practical Quantitation Limit.

U - Above the upper calibration limit.



U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

=====

PRODUCED ON 02/24/92  
07:49  
HOP BROOK LAKE, CT (9/30/91)

METHOD 8270: SEMI-VOLATILE ORGANICS (ug/L)

*****					
*	*	14971	14973	METHOD	*
*	PARAMETER	HB-14	HB05	BLANK	*
*		W	W	W	*
*****					
* Aniline	*	< 48	< 47	< 50	*
* Phenol	*	< 9.5	< 9.5	< 10	*
* Bis(2-chloroethyl)ether	*	< 9.5	< 9.5	< 10	*
* 2-Chlorophenol	*	< 9.5	< 9.5	< 10	*
* 1,3-Dichlorobenzene	*	< 9.5	< 9.5	< 10	*
* 1,4-Dichlorobenzene	*	< 9.5	< 9.5	< 10	*
* 1,2-Dichlorobenzene	*	< 9.5	< 9.5	< 10	*
* Benzyl alcohol	*	< 19	< 19	< 20	*
* 2-Methylphenol	*	< 9.5	< 9.5	< 10	*
* Bis(2-chloroisopropyl)ether	*	< 9.5	< 9.5	< 10	*
* 4-Methylphenol	*	< 9.5	< 9.5	< 10	*
* N-Nitroso-di-n-propylamine	*	< 9.5	< 9.5	< 10	*
* Hexachloroethane	*	< 9.5	< 9.5	< 10	*
* Nitrobenzene	*	< 9.5	< 9.5	< 10	*
* Isophrone	*	< 9.5	< 9.5	< 10	*
* 2-Nitrophenol	*	< 9.5	< 9.5	< 10	*
* 2,4-Dimethylphenol	*	< 9.5	< 9.5	< 10	*
* Benzoic acid	*	< 48	< 47	< 50	*
* Bis(2-chloroethoxy)methane	*	< 9.5	< 9.5	< 10	*
* 2,4-Dichlorophenol	*	< 9.5	< 9.5	< 10	*
* 1,2,4-Trichlorobenzene	*	< 9.5	< 9.5	< 10	*
* Napthalene	*	< 9.5	< 9.5	< 10	*
* 4-Chloroaniline	*	< 19	< 19	< 20	*
* Hexachlorobutadiene	*	< 9.5	< 9.5	< 10	*
* 4-Chloro-3-methylphenol	*	< 19	< 19	< 20	*
* 2-Methylnapthalene	*	< 9.5	< 9.5	< 10	*
* Hexachlorocyclopentadiene	*	< 9.5	< 9.5	< 10	*
* 2,4,6-Trichlorophenol	*	< 9.5	< 9.5	< 10	*
* 2,4,5-Trichlorophenol	*	< 9.5	< 9.5	< 10	*
* 2-Chloronapthalene	*	< 9.5	< 9.5	< 10	*
* 2-Nitroaniline	*	< 48	< 47	< 50	*
* Dimethylphthalate	*	< 9.5	< 9.5	< 10	*
* Acenaphthylene	*	< 9.5	< 9.5	< 10	*
* 3-Nitroaniline	*	< 48	< 47	< 50	*
* Acenaphthene	*	< 9.5	< 9.5	< 10	*
* 2,4-Dinitrophenol	*	< 48	< 47	< 50	*
* 4-Nitrophenol	*	< 48	< 47	< 50	*
* Dibenzofuran	*	< 9.5	< 9.5	< 10	*
* 2,6-Dinitrotoluene	*	< 9.5	< 9.5	< 10	*
* 2,4-Dinitrotoluene	*	< 9.5	< 9.5	< 10	*
* Diethylphthalate	*	< 9.5	< 9.5	< 10	*
*****					

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

=====

PRODUCED ON 02/24/92  
07:49

HOP BROOK LAKE, CT (9/30/91)

METHOD 8270: SEMI-VOLATILE ORGANICS (ug/L)

*****						
*		14971	14973	METHOD	*	
*	PARAMETER	HB-14	HB05	BLANK	*	
*		W	W	W	*	
*****						
*	4-Chlorophenyl-phenylether	< 9.5	< 9.5	< 10	*	
*	Fluorene	< 9.5	< 9.5	< 10	*	
*	4-Nitroaniline	< 48	< 47	< 50	*	
*	4,6-Dinitro-2-methylphenol	< 48	< 47	< 50	*	
*	N-Nitrosodiphenylamine	< 9.5	< 9.5	< 10	*	
*	1,2-Diphenylhydrazine	< 9.5	< 9.5	< 10	*	
*	4-Bromophenyl-phenylether	< 9.5	< 9.5	< 10	*	
*	Hexachlorobenzene	< 9.5	< 9.5	< 10	*	
*	Pentachlorophenol	< 48	< 47	< 50	*	
*	Phenanthrene	< 9.5	< 9.5	< 10	*	
*	Anthracene	< 9.5	< 9.5	< 10	*	
*	Di-n-butylphthalate	< 9.5	< 9.5	< 10	*	
*	Fluoranthene	< 9.5	< 9.5	< 10	*	
*	Pyrene	< 9.5	< 9.5	< 10	*	
*	Butylbenzylphthalate	< 9.5	< 9.5	< 10	*	
*	3,3-Dichlorobenzidine	< 19	< 19	< 20	*	
*	Benzo(a)anthracene	< 9.5	< 9.5	< 10	*	
*	Bis(2ethylhexyl)phthalate	< 9.5	< 9.5	< 10	*	
*	Chrysene	< 9.5	< 9.5	< 10	*	
*	Di-n-octyl phthalate	1.6	20	5.9	*	
*	Benzo(b)fluoranthene	< 9.5	< 9.5	< 10	*	
*	Benzo(k)fluoranthene	< 9.5	< 9.5	< 10	*	
*	Benzo(a)pyrene	< 9.5	< 9.5	< 10	*	
*	Indeno(1,2,3-cd)pyrene	< 9.5	< 9.5	< 10	*	
*	Dibenz(a,h)anthracene	< 9.5	< 9.5	< 10	*	
*	Benzo(g,h,i)perylene	< 9.5	< 9.5	< 10	*	
*****						
*	DILUTION FACTOR	0.95	0.95	1.0	*	
*****						
*	SURROGATE STANDARD RECOVERY (%):					*
*	Nitrobenzene-d5 (35-114)	81	79	86	*	
*	2-Fluorobiphenyl (43-116)	69	64	69	*	
*	4-terphenyl-d14 (33-141)	109	99	103	*	
*	2-Fluorophenol (10- 94)	62	61	69	*	
*	Phenol-d6 (21-100)	58	57	66	*	
*	2,4,6-Tribromophenol (10-123)	65	65	63	*	
*****						
	SAMPLE DATE:	9/30/91	9/30/91			
	DATE EXTRACTED:	10/9/91	10/9/91	10/9/91		
	DATE ANALYZED:	10/16/91	10/16/91	10/16/91		

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

=====

PRODUCED ON 02/24/92  
07:49  
HOP BROOK LAKE, CT (9/30/91)

METHOD 8270: SEMI-VOLATILE ORGANICS (mg/kg)

*****					
*	*	14972	14974	METHOD	*
*	PARAMETER	HB-14	HB05	BLANK	*
*	*	S	S	S	*
*****					
* Aniline	*	< 0.25	< 0.21	< 0.17	*
* Phenol	*	< 0.051	< 0.042	< 0.033	*
* Bis(2-chloroethyl)ether	*	< 0.051	< 0.042	< 0.033	*
* 2-Chlorophenol	*	< 0.051	< 0.042	< 0.033	*
* 1,3-Dichlorobenzene	*	< 0.051	< 0.042	< 0.033	*
* 1,4-Dichlorobenzene	*	< 0.051	< 0.042	< 0.033	*
* 1,2-Dichlorobenzene	*	< 0.051	< 0.042	< 0.033	*
* Benzyl alcohol	*	< 0.10	< 0.082	< 0.065	*
* 2-Methylphenol	*	< 0.051	< 0.042	< 0.033	*
* Bis(2-chloroisopropyl)ether	*	< 0.051	< 0.042	< 0.033	*
* 4-Methylphenol	*	< 0.051	< 0.042	< 0.033	*
* N-Nitroso-di-n-propylamine	*	< 0.051	< 0.042	< 0.033	*
* Hexachloroethane	*	< 0.051	< 0.042	< 0.033	*
* Nitrobenzene	*	< 0.051	< 0.042	< 0.033	*
* Isophrone	*	< 0.051	< 0.042	< 0.033	*
* 2-Nitrophenol	*	< 0.051	< 0.042	< 0.033	*
* 2,4-Dimethylphenol	*	< 0.051	< 0.042	< 0.033	*
* Benzoic acid	*	< 0.25	< 0.21	< 0.17	*
* Bis(2-chloroethoxy)methane	*	< 0.051	< 0.042	< 0.033	*
* 2,4-Dichlorophenol	*	< 0.051	< 0.042	< 0.033	*
* 1,2,4-Trichlorobenzene	*	< 0.051	< 0.042	< 0.033	*
* Napthalene	*	J 0.030	J 0.014	< 0.033	*
* 4-Chloroaniline	*	< 0.10	< 0.082	< 0.065	*
* Hexachlorobutadiene	*	< 0.051	< 0.042	< 0.033	*
* 4-Chloro-3-methylphenol	*	< 0.10	< 0.082	< 0.065	*
* 2-Methylnapthalene	*	J 0.024	J 0.011	< 0.033	*
* Hexachlorocyclopentadiene	*	< 0.051	< 0.042	< 0.033	*
* 2,4,6-Trichlorophenol	*	< 0.051	< 0.042	< 0.033	*
* 2,4,5-Trichlorophenol	*	< 0.051	< 0.042	< 0.033	*
* 2-Chloronapthalene	*	< 0.051	< 0.042	< 0.033	*
* 2-Nitroaniline	*	< 0.25	< 0.21	< 0.17	*
* Dimethylphthalate	*	< 0.051	< 0.042	< 0.033	*
* Acenaphthylene	*	J 0.027	J 0.0088	< 0.033	*
* 3-Nitroaniline	*	< 0.25	< 0.21	< 0.17	*
* Acenaphthene	*	J 0.015	< 0.042	< 0.033	*
* 2,4-Dinitrophenol	*	< 0.25	< 0.21	< 0.17	*
* 4-Nitrophenol	*	< 0.25	< 0.21	< 0.17	*
* Dibenzofuran	*	J 0.022	J 0.0095	< 0.033	*
* 2,6-Dinitrotoluene	*	< 0.051	< 0.042	< 0.033	*
* 2,4-Dinitrotoluene	*	< 0.051	< 0.042	< 0.033	*
* Diethylphthalate	*	0.22	0.29	< 0.033	*
*****					

U.S. ARMY CORPS OF ENGINEERS  
NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 02/24/92  
07:49

HOP BROOK LAKE, CT (9/30/91)

METHOD 8270: SEMI-VOLATILE ORGANICS (mg/kg)

*****				
*	*	14972	14974	METHOD
*	PARAMETER	HB-14	HB05	BLANK
*	*	S	S	S
*****				
*	4-Chlorophenyl-phenylether	< 0.051	< 0.042	< 0.033
*	Fluorene	J 0.047	J 0.022	< 0.033
*	4-Nitroaniline	< 0.25	< 0.21	< 0.17
*	4,6-Dinitro-2-methylphenol	< 0.25	< 0.21	< 0.17
*	N-Nitrosodiphenylamine	< 0.051	< 0.042	< 0.033
*	1,2-Diphenylhydrazine	< 0.051	< 0.042	< 0.033
*	4-Bromophenyl-phenylether	< 0.051	< 0.042	< 0.033
*	Hexachlorobenzene	< 0.051	< 0.042	< 0.033
*	Pentachlorophenol	< 0.25	< 0.21	< 0.17
*	Phenanthrene	> 0.59	0.30	< 0.033
*	Anthracene	J 0.072	J 0.038	< 0.033
*	Di-n-butylphthalate	0.60	0.32	0.090
*	Fluoranthene	0.99	0.24	< 0.033
*	Pyrene	2.0	0.64	< 0.033
*	Butylbenzylphthalate	< 0.051	< 0.042	< 0.033
*	3,3-Dichlorobenzidine	< 0.10	< 0.082	< 0.065
*	Benzo(a)anthracene	0.42	0.15	< 0.033
*	Bis(2ethylhexyl)phthalate	0.52	0.41	< 0.033
*	Chrysene	0.63	0.22	< 0.033
*	Di-n-octyl phthalate	0.26	< 0.042	0.27
*	Benzo(b)fluoranthene	0.45	0.16	< 0.033
*	Benzo(k)fluoranthene	0.45	0.16	< 0.033
*	Benzo(a)pyrene	0.42	0.12	< 0.033
*	Indeno(1,2,3-cd)pyrene	0.68	< 0.042	< 0.033
*	Dibenz(a,h)anthracene	< 0.051	< 0.042	< 0.033
*	Benzo(g,h,i)perylene	0.29	< 0.042	< 0.033
*****				
*	DILUTION FACTOR	0.077	0.063	0.050
*****				
*	SURROGATE STANDARD RECOVERY (%):			
*	Nitrobenzene-d5 (23-120)	46	100	93
*	2-Fluorobiphenyl (30-115)	54	120	106
*	4-terphenyl-d14 (18-137)	99	97	122
*	2-Fluorophenol (25-121)	49	64	41
*	Phenol-d6 (24-113)	78	92	61
*	2,4,6-Tribromophenol (19-122)	32	33	8.0
*****				

SAMPLE DATE:	9/30/91	9/30/91	
DATE EXTRACTED:	10/7/91	10/7/91	10/14/91
DATE ANALYZED:	11/2/91	10/19/91	10/17/91

J - Estimated value; analyte detected at < the Practical Quantitation Limit.

APPENDIX B

HOP BROOK LAKE  
PRIORITY POLLUTANT SCAN  
STANDARDS AND DATA SUMMARIES  
TABLES 6 - 46

TABLE 6  
STANDARDS AND DATA SUMMARY FOR  
PCBs

Range at Hop Brook Lake

Water - <0.000050 ppm  
Sediment - 0.020 to 0.090 ppm

Drinking Water Standards

Primary - 0.0005 ppm  
Secondary - NA  
MCLG - NA

Freshwater Aquatic Life Criteria

Acute - NA  
Chronic - 0.000014 ppm

Lowest Reported Toxic Concentration

Freshwater  
Acute - 0.002 ppm  
Chronic - NA  
Saltwater  
Acute - 0.01 ppm  
Chronic - NA

Great Lakes Sediment Guidelines

Nonpolluted - NA  
Moderately Polluted - NA  
Heavily Polluted - >10 ppm

MA DEQE - DWPC Sediment Classification

Type I - <0.5 ppm  
Type II - 0.5-1.0 ppm  
Type III - >1.0 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 12 ppm  
Sediment Cleanup Standards - 65 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 2.4 ppm  
Sediment Cleanup Standards - 13 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 1.2 ppm  
Sediment Cleanup Standards - 6.5 ppm

Biological Sediment Effects

ER-L - 0.050 ppm  
ER-M - 0.40 ppm  
AET - NA  
Start of Biological Effects - >0.003 ppm

TABLE 6  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
PCBs

Background Concentrations in Soils/Sediments

Pacific Coast to Continental Divide - 0.0022 to 0.020 ppm

Appalachian Mountain-Atlantic Coast - 0.1 to 0.5 ppm

Atmospheric Deposition in South Carolina Marsh Sediment

Mean - 0.0026 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - <0.0025 to 250 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - 0.068 to 0.27 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - <0.0043 to 0.017 ppm

Notes:

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with PCBs.

TABLE 7

STANDARDS AND DATA SUMMARY FOR  
DIOXINS AND FURANS

Hop Brook Lake, Station HB14, Sediment

OctaCDD - 2.9 ppb

Total PCDD - <3.2 ppb

Total PCDD/PCDF - <4 ppb

Drinking Water Standards - N/A

Freshwater Aquatic Life Criteria - N/A

Maximum Levels at Other NED Projects

Birch Hill Dam, Massachusetts

Contaminated Sediments

HexaCDD - 0.073 ppb

HeptaCDD - 1.5 ppb

OctaCDD - 11 ppb

Total PCDD - 12.6 ppb

HexaCDF - 0.12 ppb

HeptaCDF - 0.059 ppb

OctaCDF - 1.0 ppb

Total PCDF - 1.2 ppb

Total PCDD/PCDF - 13.8 ppb

Background Sediments

OctaCDD - 0.41 ppb

Total PCDD - 0.41 ppb

Thomaston Dam, CT - No Detectable Concentrations

Otter Brook Lake, NH - No Detectable Concentrations

West Hill Dam, MA - No Detectable Concentrations

Background Concentrations in Soils/Sediments

Most US Soils - < 0.002 ppb TCDD

15 Urban US Soils - 0.05 to 9.1 ppb PCDD/PCDF

Lake Ontario Sediments - 0.003 to 0.013 ppb TCDD

Rural Michigan Soils - < 1 ppb PCDD/PCDF

Lake Huron Sediments - 0.56 to 0.9 ppb PCDD/PCDF

Mean Lake Huron Sediments - 0.87 ppb OCDD

Mean Lake Michigan Sediments - 0.90 ppb OCDD

Lake Zurich Sediments - 1.7 ppb PCDD/PCDF

Contaminated Soils and Sediments

Love Canal, New York, Sewer and Creek Sediment

- 0.9 to 312 ppb TCDD

Horse Arenas Sprayed with Dioxin-Contaminated Oil

- 31,800 to 33,000 ppb TCDD

Times Beach, Missouri, Soil Sprayed with Dioxin-

Contaminated Oil - 0.8 to 196 ppb TCDD

Michigan Soils close to a Chemical Waste Combustion

Source - 3,000 ppb PCDD/PCDF



TABLE 8  
STANDARDS AND DATA SUMMARY FOR  
4,4'-DDT

Range at Hop Brook Lake

Water - <0.08 ppb

Sediment - 12 to 15 ppb

Drinking Water Standards - NA

Existing Freshwater Aquatic Life Criteria - DDT & metabolites

Acute - 1.1 ppb

Chronic - 0.001 ppb

Proposed Freshwater Aquatic Life Criteria - DDT & metabolites

Acute - 0.021 ppb

Chronic - 0.0067 ppb

Proposed Freshwater Aquatic Life Criteria - DDT

Acute - 0.00023 ppb

Chronic - 0.41 ppb

Biological Sediment Effects

ER-L - 1 ppb

ER-M - 7 ppb

AET - 6 ppb

WQ criteria based on sediment/water partitioning (1% TOC)

Acute - 210 ppb

Chronic - 1.6 ppb

Range at Other NED Projects

Thomaston Dam, Connecticut

Sediment - J 6.6 to 27 ppb

Otter Brook Lake, New Hampshire

Sediment - Not Detected at 6.9 ppb detection limit

Concentrations in Soils/Sediments

US National Monitoring Program

1976 to 1980 - 110.6 ppb max conc.

FY73 - 10 to 18,930 ppb; ave. 130 ppb

FY91, urban soils - 10 to 5,860 ppb

STORET Database - 0.1 ppb median conc.

Lake Michigan - 0.11 to 13 ppb

Southern Lake Michigan - median 9.3 ppb

Virgin Islands cisterns - 90 to 271,000 ppb;

median 2,770 ppb

Atmospheric Deposition, North Inlet, S. Carolina 1974-75

Rain - 0.0008 ppb ave.

Sediment - 3.4 ppb ave.

Fields with Regular Pesticide Use

Vegetable and Cotton - 290 to 15,600 ppb

Fruit Tree - 70 to 245,000 ppb

Small Grain and Root Crop - 10 to 9,230 ppb

TABLE 9

STANDARDS AND DATA SUMMARY FOR  
4,4'-DDE

Range at Hop Brook Lake

Water - <0.080 ppb

Sediment - <6.4 to 15 ppb

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria

Acute - 1.1 ppb

Chronic - 0.001 ppb

Biological Sediment Effects

ER-L - 2 ppb

ER-M - 15 ppb

AET - NA

Acute WQ criteria based on sediment/water partitioning -  
7,000 ppb

Range at Other NED Projects

Thomaston Dam, Connecticut

Sediment - 8.4 to <16 ppb

Otter Brook Lake - New Hampshire

Sediment - J1.4 to <6.9 ppb

Concentrations in Soils/Sediments

US National Monitoring Program

1976 to 1980 - 163 ppb max conc.

FY73 - 10 to 7,160 ppb; ave. 50 ppb

FY72 - 10 to 54,980 ppb; ave. 110 ppb

STORET Database - 0.1 ppb median conc.

Upper Great Lakes - 2 to 7 ppb

Ohio River Valley - 1.1 to 4.1 ppb

Lake Michigan - 0.06 to 4.82 ppb; 1.2 ppb ave. conc.

Ontario Orchards - 20 to 33,300 ppb; ave. 4,300 ppb

TABLE 10  
STANDARDS AND DATA SUMMARY FOR  
4,4'-DDD

Range at Hop Brook Lake

Water - <0.08 ppb

Sediment - <6.4 to 17 ppb

Drinking Water Standards - NA

Existing Freshwater Aquatic Life Criteria - DDT & metabolites

Acute - 1.1 ppb

Chronic - 0.001 ppb

Proposed Freshwater Aquatic Life Criteria - DDT & metabolites

Acute - 0.021 ppb

Chronic - 0.0067 ppb

Biological Sediment Effects

ER-L - 2 ppb

ER-M - 20 ppb

AET - NA

WQ criteria based on sediment/water partitioning (1% TOC)

Acute - 3,250 ppb

Range at other NED projects

Otter Brook Lake, New Hampshire

Sediment - <6.9 to 8 ppb

Thomaston Lake, Connecticut

Sediment - 9.1 to 24 ppb

Concentrations in Soils/Sediments

US National Soils Monitoring Program

FY92, 37 states - 10 to 38,460; ave. 50 ppb

FY91, 5 cities - 10 to 6,570; ave. 100 ppb

8 US cities - 10 to 5,060; ave. 120 ppb

STORET Database - 0.2 ppb median conc.

Undisturbed Californian Coastal Sediments

1955 - 12 ppb

1976 - 18 ppb

Lake Michigan Sediments

1970-71 - 0.01 to 12.6; ave. 3.04 ppb

1971 - 0.02 to 5.47; ave. 1.01 ppb

Potomac River Basin Sediments - 0.8 to 640; ave. 104 ppb

Agricultural Areas

US Rice-Growing Areas - 10 to 940; ave. 50 ppb

Japanese Field Soils - 18 to 1,554 ppb

TABLE 11  
STANDARDS AND DATA SUMMARY FOR  
ALUMINUM

Range at Hop Brook Lake

Water - 0.25 to 0.26 ppm

Sediment - 3,500 to 34,000 ppm

Drinking Water Standards

Primary - NA

Secondary - 0.05 ppm (proposed)

MCLG - NA

Freshwater Aquatic Life Criteria<sup>1</sup>

Acute - 0.75 ppm

Chronic - 0.087 ppm

Lowest Reported Toxic Concentration - NA

Great Lakes Sediment Guidelines - NA

Biological Sediment Effects - NA

Levels in Sediments at Other NED Projects

Thomaston Dam, CT - 6,500 to 11,000 ppm

Otter Brook Lake, NH - 7,400 to 18,000 ppm

Mean of other NED projects - 10,700 ppm

Concentrations in Soils

Earth's Crust - 80,000 ppm (8 percent)

Average Abundance in Shale - 80,000 ppm

Background Concentrations in Michigan Soils

Range - 400 to 17,600 ppm

Mean - 4,900 ppm

<sup>1</sup>For pH in the range 6.5 to 9.0

TABLE 12  
STANDARDS AND DATA SUMMARY FOR  
ANTIMONY

Range at Hop Brook Lake

Water - ND (<0.11 ppm)

Sediment - J 3.1 to J 68 ppm

Drinking Water Standards

Primary - 0.01 ppm (proposed)

Secondary - NA

MCLG - 0.003 ppm (proposed)

Freshwater Aquatic Life Criteria (Antimony +III)

Acute - 0.0088 ppm

Chronic - 0.003 ppm

Lowest Reported Toxic Concentration

Freshwater

Acute - 9 ppm

Chronic - 1.6 ppm

Saltwater - NA

Great Lakes Sediment Guidelines - NA

Biological Sediment Effects

ER-L - 2 ppm

ER-M - 25 ppm

AET - 25 ppm

Levels in Sediments at Other NED Projects

Thomaston Dam, CT - <0.90 ppm

Otter Brook Lake, NH - J13 to J67 ppm

Mean of other NED projects - J20 ppm

Concentrations in Soils

Earth's Crust - 1 ppm

Average Abundance in Shale - 1.5 ppm

Background Concentrations in Michigan Soils

Range - < 0.025 to 23 ppm

Mean - 5.9 ppm

Concentrations in Sediments - NA

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

TABLE 13

STANDARDS AND DATA SUMMARY FOR  
ARSENIC

Range at Hop Brook Lake

Water - <0.0050 ppm

Sediment - 0.88 to 2.2 ppm

Drinking Water Standards

Primary - 0.05 ppm

Secondary - NA

MCLG - 0.05 ppm

Freshwater Aquatic Life Criteria

Acute - 0.36 ppm (Arsenic III)

Chronic - 0.19 ppm (Arsenic III)

Great Lakes Sediment Guidelines

Nonpolluted - <3 ppm

Moderately Polluted - 3 to 8 ppm

Heavily Polluted - >8 ppm

MA DEQE - DWPC Sediment Classification

Type I - <10 ppm

Type II - 10-20 ppm

Type III - >20 ppm

Sediment Management Standards for the State of Washington

Sediment Quality Standards - 57 ppm

Sediment Cleanup Standards - 93 ppm

Biological Sediment Effects

ER-L - 33 ppm

ER-M - 85 ppm

AET - 50 ppm

Concentrations in Soils

Earth's Crust - 1.81 to 6 ppm

Background Concentrations in Michigan Soils

Range - 0.006 to 39 ppm

Mean - 2.5 ppm

Background Concentrations in Ontario Soils

Range - 5.8 to 6.4 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

French River, CT - 2.1 to 31.4; mean 16.65 ppm

Ashtabula River, OH - 12 to 56; mean 28.9 ppm

Blackstone River, MA - 3 ppm.

TABLE 13  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
ARSENIC

Concentrations in Sediments

Polluted

Oxoboxo River, CT - 8 to 16; mean 11 ppm  
North River, MA - 0.8 ppm  
Quinsigamond River, MA - 4.2 ppm

Clean

Oak Orchard Harbor, NY - 2.1 to 5.7; mean 3.2 ppm  
Winnepesaukee River, NH - 2.3 to 2.6 ppm  
South River, MA - 0.2 ppm  
Lake Quinsigamond - 94 ppm

Unclassified

Gulf of Maine Dredged Harbors  
Number - 598  
Mean - 6.98 ppm  
Mean plus 2 standard deviations - 22.3 ppm  
Cape Cod to Western Connecticut Dredged Harbors  
Number - 598  
Mean - 7.3 ppm  
Mean plus 2 standard deviations - 24.7 ppm  
16 Massachusetts Lakes  
Mean 14.1 ppm  
Range 0.7 to 43 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)  
Range - 0.9 to 2.5 ppm  
Mean - 1.9 ppm  
Thomaston Dam, CT (Lightly Contaminated Sediments)  
Range - 1.4 to 1.7 ppm  
Mean - 1.55 ppm  
Hopkinton Lake, NH (Clean Sediments)  
Range - 2.3 to 3.9 ppm  
Mean - 3.1 ppm  
Otter Brook Lake, NH (Clean Sediments)  
Range - 0.6 to 0.7 ppm  
Mean - 0.65 ppm  
Mean of all Other NED Projects - 1.8 ppm

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with arsenic.

TABLE 14

STANDARDS AND DATA SUMMARY FOR  
BARIUM

Range at Hop Brook Lake

Water - 0.020 to 0.021 ppm

Sediment - 18 to 210 ppm

Drinking Water Standards

Primary - 2 ppm

Secondary - NA

MCLG - 2 ppm

Freshwater Aquatic Life Criteria - NA

Lowest Reported Toxic Concentration - NA

Biological Sediment Effects - NA

Great Lakes Sediment Guidelines

Nonpolluted - <20 ppm

Moderately Polluted - 20 to 60 ppm

Heavily Polluted - >60 ppm

Concentrations in Soils

Earth's Crust - 400 ppm

Background Concentrations in Michigan Soils

Range - 1.05 to 291 ppm

Mean - 49 ppm

Average Concentration in Shale - 600 ppm.

863 Samples of Top 8" of US Soils -

Range - 10 to 1,500 ppm

Mean - 430 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

Ashtabula River, OH - 200 to 1,160 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - 22.1 to 61.6 ppm

Mean - 41.0 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - 37 to 120 ppm

Mean - 78 ppm

Hopkinton Lake, NH (Clean Sediments)

Range - 59.3 to 68 ppm

Mean - 63.9 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - 36 to 110 ppm

Mean - 73 ppm

Mean of all Other NED Projects - 64 ppm

<sup>1</sup>Based on overall condition; these sediments were not necessarily contaminated with barium.



TABLE 15  
STANDARDS AND DATA SUMMARY FOR  
BERYLLIUM

Range at Hop Brook Lake

Water - <0.0040 ppm

Sediment - 0.17 to 1.8 ppm

Drinking Water Standards

Primary - 0.001 ppm (proposed)

Secondary - NA

MCLG - 0 (proposed)

Freshwater Aquatic Life Criteria - NA

Lowest Reported Toxic Concentration

Freshwater

Acute - 0.13 ppm

Chronic - 0.0053 ppm

Saltwater - NA

Great Lakes Sediment Guidelines - NA

Biological Sediment Effects - NA

Concentrations in Soils

Earth's Crust - 50 ppm

Background Concentrations in Michigan Soils

Range - 0.1 to 1.4 ppm

Mean - 0.5 ppm

Concentrations at Other NED Projects

Otter Brook Lake, NH

Range - 0.45 to J 0.55 ppm

Mean - 0.50 ppm

Thomaston Dam, CT

Range - 0.56 to 0.78 ppm

Mean - 0.67 ppm

Mean at Other NED Projects - 0.58 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

TABLE 16

STANDARDS AND DATA SUMMARY FOR  
CADMIUM

Range at Hop Brook Lake

Water - <0.0050 ppm

Sediment - <0.5 to 3.4 ppm

Drinking Water Standards

Primary - 0.005 ppm

Secondary - NA

MCLG - 0.005 ppm

Freshwater Aquatic Life Criteria

Acute - 0.00047 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Chronic - 0.0011 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Great Lakes Sediment Guidelines

Nonpolluted - NA

Moderately Polluted - NA

Heavily Polluted - >6 ppm

MA DEQE - DWPC Sediment Classification

Type I - <5 ppm

Type II - 5-10 ppm

Type III - >10 ppm

Sediment Management Standards for the State of Washington

Sediment Quality Standards - 5.1 ppm

Sediment Cleanup Standards - 6.7 ppm

Biological Sediment Effects

ER-L - 5 ppm

ER-M - 9 ppm

AET - 5 ppm

Concentrations in Soils

Earth's Crust - 0.01 to 0.7 ppm

Background Concentrations in Michigan Soils

Range - <0.025 to 4.1 ppm

Mean - 0.9 ppm

Industrial Northwest Indiana Soils

Surficial Samples

Urban Areas - 12.2 ppm

Rural Areas - 0.6 ppm

Samples from 30-36 cm, all samples - 0.1 to 0.2 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

French River, CT - 0.7 to 25; mean 7.35 ppm

Ashtabula River, OH - 5 to 9; mean 6.1 ppm

Blackstone River, MA - median 17; max. 150 ppm

TABLE 16  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
CADMIUM

Concentrations in Sediments

Polluted

Oxoboxo River, CT - <2 to 14; mean 9 ppm  
North River, MA - median 0.9; max. 5.5 ppm  
Quinsigamond River, MA - median 0.3; max. 0.6 ppm

Clean

Oak Orchard Harbor, NY - 0.6 to 2.4; mean 2.1 ppm  
South River, MA - median 0.2; max. 0.3 ppm  
Lake Quinsigamond - median 2.9; max. 5.5 ppm

Unclassified

Gulf of Maine Dredged Harbors  
Number - 597  
Mean - 3.12 ppm  
Mean plus 2 standard deviations - 15.6 ppm  
Cape Cod to Western Connecticut Dredged Harbors  
Number - 601  
Mean - 5.9 ppm  
Mean plus 2 standard deviations - 26.9 ppm  
16 Massachusetts Lakes  
Mean - 2.6 ppm  
Maximum - 7.1 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)  
Range - NA  
Mean - 0.45 ppm  
Thomaston Dam, CT (Lightly Contaminated Sediments)  
Range - J 1.2 to J 3.6 ppm  
Mean - J 2.4 ppm  
Otter Brook Lake, NH (Clean Sediments)  
Range - J 0.43 to J 1.2 ppm  
Mean - J 0.82 ppm  
Hopkinton Lake, NH (Clean Sediments)  
Range - <2 ppm  
Mean - 3 ppm  
Mean at all Other NED Projects - J 1.6 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with cadmium.

TABLE 17

STANDARDS AND DATA SUMMARY FOR  
CHROMIUM

Range at Hop Brook Lake

Water - <0.015 ppm

Sediment - J 4.6 to 48 ppm

Drinking Water Standards

Primary - 0.1 ppm

Secondary - NA

Freshwater Aquatic Life Criteria

Chromium(VI)

Acute - 0.011 ppm

Chronic - 0.016 ppm

Chromium(III)

Acute - 0.083 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Chronic - 0.70 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Great Lakes Sediment Guidelines

Nonpolluted - <25 ppm

Moderately Polluted - 25 to 75 ppm

Heavily Polluted - >75 ppm

MA DEQE - DWPC Sediment Classification

Type I - <100 ppm

Type II - 100-300 ppm

Type III - >300 ppm

Sediment Management Standards for the State of Washington

Sediment Quality Standards - 260 ppm

Sediment Cleanup Standards - 270 ppm

Biological Sediment Effects

ER-L - 80 ppm

ER-M - 145 ppm

AET - NA

Concentrations in Soils

Earth's Crust - 5 to 3,000 ppm

Range in US soils - 1 to 1,500 ppm

Background Concentrations in Michigan Soils

Range - 0.56 to 58 ppm

Mean - 11.8 ppm

Average Concentration in Shale - 100 ppm

TABLE 17  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
CHROMIUM

Concentrations in Sediments

Highly Polluted<sup>1</sup>

French River, CT - 23 to 4,710; mean 1,370 ppm  
Ashtabula River, OH - 64 to 69; mean 312 ppm  
Blackstone River, MA - median 130, max. 900 ppm

Polluted

Oxoboxo River, CT - 34 to 83; mean 61.6 ppm  
North River, MA - median 9.8, max. 363 ppm  
Quinsigamond River, MA - median 16, max. 40 ppm

Clean

Oak Orchard Harbor, NY - 6.4 to 12; mean 9.0 ppm  
Winnepesaukee River, NH - 12 to 13 ppm  
South River, MA - median 6.2, max. 7.5 ppm  
Lake Quinsigamond - median 34, max. 73 ppm

Unclassified

Gulf of Maine Dredged Harbors

Number - 597  
Mean - 112 ppm  
Mean plus 2 standard deviations - 563 ppm

Cape Cod to Western Connecticut Dredged Harbors

Number - 598  
Mean - 160 ppm  
Mean plus 2 standard deviations - 783 ppm

16 Massachusetts Lakes

Mean - 36 ppm  
Range - 5 to 150 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - 4.4 to 24.9 ppm  
Mean - 10.3 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - 26 to 52 ppm  
Mean - 39 ppm

Hopkinton Lake, NH (Clean Sediments)

Range - 22 to 32 ppm  
Mean - 27 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - 16 to 40 ppm  
Mean - 28 ppm

Mean at all Other NED Projects - 26.1 ppm

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with chromium.

TABLE 18

STANDARDS AND DATA SUMMARY FOR  
COBALT

Range at Hop Brook Lake

Water - J 0.018 to J 0.021 ppm

Sediment - J 3.0 to J 20 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Reported Toxic Concentration - NA

Great Lakes Sediment Guidelines - NA

Biological Sediment Effects - NA

Concentrations in Soils

Earth's Crust - 10 ppm

Background Concentrations in Michigan Soils

Range - <1.25 to 18 ppm

Mean - 5.8 ppm

Concentrations in Sediments

Merrimack River, NH - 2 ppm

Concentrations at Other NED Projects

Thomaston Dam, CT

Range - J 8.7 to J 12 ppm

Mean - 10.3 ppm

Otter Brook Lake, NH

Range - J 4.5 to J 17 ppm

Mean - 10.8 ppm

Notes:

J - Estimated value; analyte detected at less than the  
Practical Quantitation Limit.

TABLE 19

STANDARDS AND DATA SUMMARY FOR  
COPPER

Range at Hop Brook Lake

Water - J 0.0010 to J 0.0092 ppm  
Sediment - 13 to 39 ppm

Drinking Water Standards

Primary - NA  
Secondary - 1 ppm (proposed)  
MCLG - 1.3 ppm

Federal Freshwater Aquatic Life Criteria

Acute - 0.0046 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )  
Chronic - 0.0062 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Connecticut Freshwater Aquatic Life Criteria

Acute - 0.0143 ppm  
Chronic - 0.0048 ppm

Great Lakes Sediment Guidelines

Nonpolluted - <25 ppm  
Moderately Polluted - 25 to 50 ppm  
Heavily Polluted - >50 ppm

MA DEQE - DWPC Sediment Classification

Type I - <200 ppm  
Type II - 200-400 ppm  
Type III - >400 ppm

Sediment Management Standards for the State of Washington

Sediment Quality Standards - 390 ppm  
Sediment Cleanup Standards - 390 ppm

Biological Sediment Effects

ER-L - 70 ppm  
ER-M - 390 ppm  
AET - 300 ppm

Concentrations in Soils

Earth's Crust - 2 to 100 ppm  
Background Concentrations in Michigan Soils  
Range - <0.1 to 74 ppm  
Mean - 12.6 ppm

Concentrations in Ontario Agricultural Soils

Range - 20 to 65 ppm  
Mean - 65 ppm

Industrial Northwest Indiana Soils

Surficial Samples

Urban Areas - 212 ppm  
Rural Areas - 75 ppm

Samples from 30-36 cm, all samples 1.5 to 3.7 - ppm

TABLE 19  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
COPPER

Concentrations in Sediments

Highly Polluted<sup>1</sup>

French River, CT - 5 to 1,790; mean 541 ppm  
Ashtabula River, OH - 34 to 69; mean 48.7 ppm  
Blackstone River, MA - median 320, max. 1,850 ppm

Polluted

Oxoboxo River, CT - 170 to 350; mean 275 ppm  
North River, MA - median 15, max. 635 ppm  
Quinsigamond River, MA - median 13, max. 21 ppm

Clean

Oak Orchard Harbor, NY - 13 to 80; mean 23 ppm  
Winnepesaukee River, NH - 13 to 15 ppm  
South River, MA - median 6, max. 8.4 ppm  
Lake Quinsigamond - median 94, max. 180 ppm

Unclassified

Gulf of Maine Dredged Harbors

Number - 591  
Mean - 83 ppm  
Mean plus 2 standard deviations - 342 ppm

Cape Cod to Western Connecticut Dredged Harbors

Number - 601  
Mean - 260 ppm  
Mean plus 2 standard deviations - 1,330 ppm

16 Massachusetts Lakes

Mean - 284 ppm  
Range - 20 to 940 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - 6.4 to 40.5 ppm  
Mean - 24.5 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - 51 to 110 ppm  
Mean - 80 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - 3.6 to 13 ppm  
Mean - 8.4 ppm

Hopkinton Lake, NH (Clean Sediments)

Range - 25 to 25.5 ppm  
Mean - 25.25 ppm

Mean at all Other NED Projects - 35 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with copper.



TABLE 20

STANDARDS AND DATA SUMMARY FOR  
IRON

Range at Hop Brook Lake

Water - 0.57 to 0.60 ppm

Sediment - 9,800 to 44,000 ppm

Drinking Water Standards

Primary - NA

Secondary - 0.3 ppm

MCLG - NA

Freshwater Aquatic Life Criteria

Acute - NA

Chronic - 1.0 ppm

Lowest Reported Toxic Concentration - NA

Great Lakes Sediment Guidelines

Nonpolluted - <17,000 ppm

Moderately Polluted - 17,000 to 25,000 ppm

Heavily Polluted - >25,000 ppm

Biological Sediment Effects - NA

Concentrations in Soils

Earth's Crust - 50,000 ppm

Background Concentrations in Michigan Soils

Range - 880 to 48,000 ppm

Mean - 11,800 ppm

Concentrations in Sediments - NA

Concentrations at Other NED Projects

Thomaston Dam, CT

Range - 10,000 to 20,000 ppm

Mean - 15,000 ppm

Otter Brook Lake, NH

Range - 12,000 to 28,000 ppm

Mean - 20,000 ppm

TABLE 21

STANDARDS AND DATA SUMMARY FOR  
LEAD

Range at Hop Brook Lake

Water - <0.0030 ppm

Sediment - 16 to 58 ppm

Drinking Water Standards

Primary - None (formerly 0.050 ppm)

Secondary - NA

MCLG - 0

Freshwater Aquatic Life Criteria

Acute - 0.020 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Chronic - 0.00078 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Great Lakes Sediment Guidelines

Nonpolluted - <40 ppm

Moderately Polluted - 40 to 60 ppm

Heavily Polluted - >60 ppm

MA DEQE - DWPC Sediment Classification

Type I - <100 ppm

Type II - 100-200 ppm

Type III - >200 ppm

Sediment Management Standards for the State of Washington

Sediment Quality Standards - 450 ppm

Sediment Cleanup Standards - 530 ppm

Biological Sediment Effects

ER-L - 35 ppm

ER-M - 110 ppm

AET - 300 ppm

Concentrations in Soils

Earth's Crust - 10 to 16 ppm

Average Abundance in Shale - 20 ppm

Lead in US Soils

Range - 10 to 700 ppm

Mean - 16 ppm

Northeastern USA Forest Soils

1980 - mean 146.3 ppm

1990 - mean 121.3 ppm

Industrial Northwest Indiana Soils

Surficial Samples

Urban Areas - 755 ppm

Rural Areas - 163 ppm

Samples from 30-36 cm, all samples - 0.2 to 0.9 ppm

TABLE 21  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
LEAD

Concentrations in Soils

Background Concentrations in Michigan Soils

Sandy Soils - <0.5 to 140; mean 9.8 ppm

Silty Soils - <2.5 to 28; mean 7.1 ppm

Clayey Soils - <0.5 to 90; mean 14 ppm

Overall - <0.5 to 140; mean - 10.3 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

French River, CT - 13 to 840; mean 358 ppm

Ashtabula River, OH - 38 to 89; mean 63.5 ppm

Blackstone River, MA - median 200, max. 980 ppm

Polluted

Oxoboxo River, CT - 12 to 340; mean 187 ppm

North River, MA - median 50, max. 300 ppm

Quinsigamond River, MA - median 45, max. 120 ppm

Clean

Oak Orchard Harbor, NY - 6.4 to 34; mean 13.9 ppm

Winnepesaukee River, NH - 88 to 93 ppm

South River, MA - median 18, max. 50 ppm

Lake Quinsigamond - median 265, max. 400 ppm

Unclassified

Gulf of Maine Dredged Harbors

Number - 598

Mean - 83 ppm

Mean plus 2 standard deviations - 285 ppm

Cape Cod to Western Connecticut Dredged Harbors

Number - 601

Mean - 145 ppm

Mean plus 2 standard deviations - 711 ppm

16 Massachusetts Lakes

Mean - 274 ppm

Range - 72 to 970 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)<sup>1</sup>

Range - 22.1 to 78.6 ppm

Mean - 46.3 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - 37 to 86 ppm

Mean - 62 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - 8.2 to 16 ppm

Mean - 8.1 ppm

TABLE 21  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
LEAD

Other NED Projects

Hopkinton Lake, NH (Clean Sediments)

Range - 65.8 to 73.4 ppm

Mean - 69.6 ppm

Mean of all Other NED Projects - 46.5 ppm

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with lead.

TABLE 22

STANDARDS AND DATA SUMMARY FOR  
MANGANESE

Range at Hop Brook Lake

Water - 0.10 to 0.17 ppm

Sediment - 95 to 810 ppm

Drinking Water Standards

Primary - NA

Secondary - 0.050 ppm

MCLG - NA

Freshwater Aquatic Life Criteria - NA

Lowest Reported Toxic Concentration - NA

Great Lakes Sediment Guidelines

Nonpolluted - <300 ppm

Moderately Polluted - 300 to 500 ppm

Heavily Polluted - >500 ppm

Biological Sediment Effects - NA

Concentrations in Soils

Earth's Crust - 1,000 ppm

Background Concentrations in Michigan Soils

Range - 11 to 4,000 ppm

Mean - 319 ppm

Concentrations in Sediments

Merrimack River - 45 to 47 ppm

Concentrations at Other NED Projects

Thomaston Dam, CT

Range - 75 to 570 ppm

Mean - 320 ppm

Otter Brook Lake, NH

Range - 51 to 100 ppm

Mean - 76 ppm

TABLE 23

STANDARDS AND DATA SUMMARY FOR  
MERCURY

Range at Hop Brook Lake

Water - <0.0003 ppm

Sediment - <0.03 to J 0.12 ppm

Drinking Water Standards

Primary - 0.002 ppm

Secondary - NA

MCLG - 0.002 ppm

Freshwater Aquatic Life Criteria

Acute - 0.0024 ppm (inorganic mercury)

Chronic - 0.12 ppm (inorganic mercury)

Great Lakes Sediment Guidelines

Nonpolluted - <1 ppm

Heavily Polluted - >/= 1 ppm

MA DEQE - DWPC Sediment Classification

Type I - <10 ppm

Type II - <10 ppm

Type III - >10 ppm

Washington State Sediment Management Standards

Sediment Quality Standards - 0.41 ppm

Sediment Cleanup Standards - 0.59 ppm

Biological Sediment Effects

ER-L - 0.15 ppm

ER-M - 1.3 ppm

AET - 1 ppm

Equilibrium Partitioning, Marine Threshold (@4% TOC)

Acute - 0.6 ppm

Chronic - 0.03 ppm

Concentrations in Soils

Earth's Crust - 0.03 to 0.5 ppm

Concentrations in United States Soils

Entire U.S.

Range - <0.01 to 4.6 ppm

Mean - 0.112 ppm

Western U.S. (West of 97th Meridian)

Range - <0.01 to 4.6 ppm

Eastern U.S.

Range - 0.010 to 3.4 ppm

Mean - 0.147 ppm

TABLE 23  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
MERCURY

Background Concentrations in Michigan Soils

Sand: Range - <0.005 to 0.13; mean - 0.04 ppm

Silt: Range - <0.029 to 0.10; mean - 0.05 ppm

Clay: Range - 0.009 to 0.70; mean - 0.06 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

Ashtabula River, OH - 0.78 to 4.7; mean 2.15 ppm

Blackstone River, MA - median 1.8; max. 6.4 ppm

Polluted

Oxoboxo River, CT - 0.09 to 1.3; mean 0.39 ppm

North River, MA - median 0.33; max. 5.5 ppm

Quinsigamond River, MA - median 0.24; max. 0.34 ppm

Clean

Oak Orchard Harbor, NY - to <0.1 to 0.2; mean 0.1 ppm

South River, MA - median 0.04; max. 0.07 ppm

Lake Quinsigamond, MA - median 0.46; max. 7 ppm

Winnepesaukee River, NH - 0.10 to 0.12 ppm

Unclassified

Gulf of Maine Dredged Harbors

Number - 597

Mean - 0.573 ppm

Mean plus 2 standard deviations - 3.0 ppm

Cape Cod to Western Connecticut Dredged Harbors

Number - 602

Mean - 0.795 ppm

Mean plus 2 standard deviations - 3.2 ppm

16 Massachusetts Lakes

Range - 0.12 to 0.40 ppm

Mean - 0.23 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - <0.04 to 0.36 ppm

Mean - 0.13 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - 0.030 to 0.14 ppm

Mean - 0.085 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - <0.030 ppm

TABLE 23  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
MERCURY

Other NED Projects

Hopkinton Lake, NH (Clean Sediments)

Range - 0.25 to 0.52 ppm

Mean - 0.38 ppm

Mean of all Other NED Projects - 0.15 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with cadmium.



TABLE 24

STANDARDS AND DATA SUMMARY FOR  
NICKEL

Range at Hop Brook Lake

Water - <0.035 ppm

Sediment - J 5.1 to J 31 ppm

Drinking Water Standards

Primary - 0.1 (proposed)

Secondary - NA

MCLG - 0.1 ppm (proposed)

Freshwater Aquatic Life Criteria

Acute - 0.56 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Chronic - 0.062 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Great Lakes Sediment Guidelines

Nonpolluted - <20 ppm

Moderately Polluted - 20 to 50 ppm

Heavily Polluted - >50 ppm

MA DEQE - DWPC Sediment Classification

Type I - <50 ppm

Type II - 50-100 ppm

Type III - >100 ppm

Biological Sediment Effects

ER-L - 30 ppm

ER-M - 50 ppm

AET - NA

Concentrations in Soils

Earth's Crust - 15 to 80 ppm

US Soils

Range - 45 to 70 ppm

Mean - 20 ppm

Background Concentrations in Michigan Soils

Range - <0.25 to 53 ppm

Mean - 14.2 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

French River, CT - 9.9 to 50.9; mean 28.5 ppm

Ashtabula River, OH - 28 to 63; mean 44.1 ppm

Blackstone River, MA - median 68, max. 320 ppm

Polluted

Oxoboxo River, CT - 20 to 40; mean 30 ppm

North River, MA - median 8.1, max. 32 ppm

Quinsigamond River, MA - median 16, max. 64 ppm

TABLE 24  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
NICKEL

Concentrations in Sediments

Clean

Oak Orchard Harbor, NY - 14 to 20; mean 18 ppm  
South River, MA - median 3.6, max. 4.2 ppm  
Lake Quinsigamond - median 46, max. 48 ppm

Unclassified

Gulf of Maine Dredged Harbors

Number - 598

Mean - 36 ppm

Mean plus 2 standard deviations - 92 ppm

Cape Cod to Western Connecticut Dredged Harbors

Number - 600

Mean - 49 ppm

Mean plus 2 standard deviations - 139 ppm

16 Massachusetts Lakes

Mean - 56 ppm

Range - 20 to 201 ppm

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - 5 to 12.3 ppm

Mean - 9 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - J 31 to J 38 ppm

Mean - 34 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - J 7.2 to J 26 ppm

Mean - 17 ppm

Hopkinton Lake, NH (Clean Sediments)

Range - 11 to 15 ppm

Mean - 13 ppm

Mean for all Other NED Projects - 18 ppm

Notes:

J - Estimated value; analyte detected at less than the  
Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their  
overall condition; these sediments were not necessarily  
contaminated with nickel.

TABLE 25

STANDARDS AND DATA SUMMARY FOR  
SILVER

Range at Hop Brook Lake

Water - <0.005 ppm

Sediment - <1.3 to 10 ppm

Drinking Water Standards

Primary - NA

Secondary - 0.1

MCLG - NA

Freshwater Aquatic Life Criteria

Acute - 0.00092 ppm

Chronic - 0.00012 ppm

Great Lakes Sediment Guidelines - NA

MA DEQE, DWPC Sediment Classification - NA

Washington State Sediment Management Standards

Sediment Quality Standards - 6.1 ppm

Sediment Cleanup Standards - 6.1 ppm

Biological Sediment Effects

ER-L - 1 ppm

ER-M - 2.2 ppm

AET - 1.7 ppm

Concentrations in Soils

Earth's Crust - 0.05 to 0.1 ppm

Background Concentrations in Michigan Soils

Sand: Range - <0.03 to 2.04; mean - 0.74 ppm

Silt: Range - <0.25 to 4.2; mean - 1.3 ppm

Clay: Range - <0.1 to 4.1; mean - 1.3 ppm

Overall Mean - 1.1 ppm

Concentrations in Sediments

Highly Polluted<sup>1</sup>

Ashtabula River, OH - 2 to 14; mean 6.4 ppm

Clean

Winnepesaukee River, NH - max. 6

Unclassified

Californian Coastal Sediments - 14 to 20 ppm

TABLE 25  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
SILVER

Other NED Projects

Birch Hill Dam, MA (Contaminated Sediments)

Range - <0.1 to 2.88; mean - 0.86 ppm

Thomaston Dam, CT (Lightly Contaminated Sediments)

Range - <1.3 ppm

Otter Brook Lake, NH (Clean Sediments)

Range - <1.3 ppm

Hopkinton Lake, NH (Clean Sediments)

Range - 0.61 to 0.72; mean - 0.66 ppm

Mean for all Other NED Projects - 0.82 ppm

Notes:

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with nickel.

TABLE 26

STANDARDS AND DATA SUMMARY FOR  
ZINC

Range at Hop Brook Lake

Water - <0.0050 ppm

Sediment - 33 to 280 ppm

Drinking Water Standards

Primary - NA

Secondary - 5 ppm (proposed)

MCLG - NA

Freshwater Aquatic Life Criteria

Acute - 0.046 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Chronic - 0.041 ppm (hardness = 33 ppm  $\text{CaCO}_3$ )

Great Lakes Sediment Guidelines

Nonpolluted - <90 ppm

Moderately Polluted - 90 to 200 ppm

Heavily Polluted - >200 ppm

MA DEQE - DWPC Sediment Classification

Type I - <200 ppm

Type II - 200-400 ppm

Type III - >400 ppm

Sediment Management Standards for the State of Washington

Sediment Quality Standards - 410 ppm

Sediment Cleanup Standards - 960 ppm

Biological Sediment Effects

ER-L - 120 ppm

ER-M - 270 ppm

AET - 260 ppm

Concentrations in Soils

Earth's Crust - 5 to 200 ppm

Background Concentrations in Michigan Soils

Sandy Soils - range <2.5 to 150; mean 28 ppm

Silty Soils - range 10 to 79; mean 33 ppm

Clayey Soils - range <0.40 to 150; mean 44 ppm

Overall Mean - 35 ppm

Industrial Northwestern Indiana Forest Soils

Surficial

Urban Areas - 2,977 ppm

Rural Areas - 476 ppm

Samples from 30-36 cm, all samples - 8 to 27 ppm

TABLE 26  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
ZINC

Concentrations in Sediments

Highly Polluted<sup>1</sup>

Ashtabula River, OH - 157 to 604 ppm

Blackstone River, MA - 88 to 4,000, median 480

Polluted

Oxoboxo River, CT - 230 to 3,000 ppm

North River, MA - 9 to 985; median 57 ppm

Quinsigamond River, MA - 48 to 92; median 47 ppm

Clean

Oak Orchard Harbor, NY - 51 to 150; mean 82 ppm

Winnepesaukee River, NH - 171 to 199 ppm

South River, MA - 11 to 17; median 16 ppm

Lake Quinsigamond - 130 to 730; median 410 ppm

Unclassified

Gulf of Maine Dredged Harbors

Number - 598

Mean - 134 ppm

Mean plus 2 standard deviations - 436 ppm

Cape Cod to Western Connecticut Dredged Harbors

Number - 601

Mean - 283 ppm

Mean plus 2 standard deviations - 1,010 ppm

Merrimack River - 23 to 27 ppm

Other NED Projects

Thomaston Dam, CT - range 140 to 280; mean 210 ppm

Otter Brook Lake, CT - range 29 to 85; mean 57 ppm

Overall Mean - 130 ppm

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with zinc.

TABLE 27

STANDARDS AND DATA SUMMARY FOR  
ACENAPHTHENE

Range at Hop Brook Lake

Water - < 0.0095 ppm

Sediment - <0.042 to J 0.015 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater

Acute - 1.7 ppm

Chronic - 0.52 ppm

Biological Sediment Effects

ER-L - 0.15 ppm

ER-M - 0.65 ppm

AET - 0.15 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 16 ppm

Sediment Cleanup Standards - 57 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 3.2 ppm

Sediment Cleanup Standards - 11 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 1.6 ppm

Sediment Cleanup Standards - 5.7 ppm

Concentrations in Sediments

Washington Coast

Range of means - <0.002 to 5 ppm

Log mean of means - 0.094 ppm

New York Harbor - 0.08 to 0.5; mean 0.34 ppm

Casco Bay, ME - 0.34 to 1.15; mean 0.85 ppm

PA streams to Lake Eire - 0.175 to 3.37; mean 0.84 ppm

Concentrations in Norwegian Soils

Unpolluted Soils - mean 0.0017 ppm

Unpolluted Bog Soils - mean 0.0038 ppm

Soils Polluted by Total PAH - mean 0.0536 ppm

TABLE 27  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
ACENAPHTHENE

Other NED Projects

Clean Sediments<sup>1</sup>

    Otter Brook Lake, NH - <0.053 ppm

Lightly Contaminated Sediments

    Thomaston Dam, CT - J 0.024 to J 0.057 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with acenaphthene.



TABLE 28

STANDARDS AND DATA SUMMARY FOR  
ACENAPHTHYLENE

Range at Hop Brook Lake

Water - < 0.0095 ppm

Sediment - J 0.0088 to J 0.027 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 66 ppm

Sediment Cleanup Standards - 66 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 13 ppm

Sediment Cleanup Standards - 13 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 6.6 ppm

Sediment Cleanup Standards - 6.6 ppm

Concentrations in Sediments

New York Harbor - max. 0.03 ppm

Casco Bay, ME - max. 1.87 ppm

PA streams to Lake Eire - max 3.26 ppm

EPA STORET Database

Median - <0.5 ppm

6 percent of 359 samples tested positive

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - <0.051 to J 0.016 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - J 0.042 to J 0.054 ppm

Notes: J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with acenaphthylene.

TABLE 29

STANDARDS AND DATA SUMMARY FOR  
ANTHRACENE

Range at Hop Brook Lake

Water - < 0.0095 ppm

Sediment - J 0.038 to J 0.072 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Saltwater

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.085 ppm

ER-M - 0.96 ppm

AET - 0.30 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 220 ppm

Sediment Cleanup Standards - 1200 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 44 ppm

Sediment Cleanup Standards - 240 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 22 ppm

Sediment Cleanup Standards - 120 ppm

Concentrations in Soils/Sediments

Buzzards Bay - 0.17 ppm

Boston Harbor - 0.008 to 0.507 ppm

Maine Coast Sediments - 0.008 ppm (maximum)

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - J 0.056 to 0.39 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 1.2 to 1.9 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with anthracene.

TABLE 30

STANDARDS AND DATA SUMMARY FOR  
BENZO(A)ANTHRACENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.15 to 0.42 ppm

Drinking Water Standards

Primary - NA

Secondary - NA

MCLG - 0.0002 ppm (proposed)

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.23 ppm

ER-M - 1.6 ppm

AET - 0.55 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 110 ppm

Sediment Cleanup Standards - 270 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 22 ppm

Sediment Cleanup Standards - 54 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 11 ppm

Sediment Cleanup Standards - 27 ppm

Concentrations in Soils/Sediments

Remote Adirondack Lakes - 0.078 to 0.36 ppm

Highway soils - 1.5 ppm

Soil contaminated with coal-tar pitch - 2.5 ppm

Buzzards Bay 0.15 miles from shore - 0.33 ppm

Buzzards Bay 1.3 miles from shore - 0.041 ppm

Atlantic Ocean Shelf - 0.0061 ppm

TABLE 30  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
BENZO(A)ANTHRACENE

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - J 0.028 to 0.18 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.68 to 1.6 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with benzo(a)anthracene.

TABLE 31

STANDARDS AND DATA SUMMARY FOR  
BENZO(A) PYRENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.12 to 0.42 ppm

Drinking Water Standards

Primary - NA

Secondary - NA

MCLG - 0.0002 ppm

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.40 ppm

ER-M - 2.5 ppm

AET - 0.70 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 99 ppm

Sediment Cleanup Standards - 210 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 20 ppm

Sediment Cleanup Standards - 42 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 9.9 ppm

Sediment Cleanup Standards - 21 ppm

Concentrations in Soils/Sediments

Remote areas of the world - 0.0015 to 1.3 ppm

MA and CT forest soils - 0.04 to 1.3 ppm

Naples, Italy polluted soil - 0.1 to 3 ppm

Moscow, Russia industrial sites - 0.35 to 11 ppm

Niagara River, New York - 0.19 to 20 ppm

Concentrations in Norwegian Soils

Unpolluted Soils - mean 0.0145 ppm

Unpolluted Bog Soils - mean 0.156 ppm

Soils Polluted by Total PAH - mean 0.321 ppm

TABLE 31  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
BENZO(A)PYRENE

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - J 0.015 to 0.12 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.56 to 1.3 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with benzo(a)pyrene.

TABLE 32

STANDARDS AND DATA SUMMARY FOR  
BENZOFLUORANTHENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment

Benzo(b)fluoranthene - 0.16 to 0.45 ppm

Benzo(k)fluoranthene - 0.16 to 0.45 ppm

Drinking Water Standards

Primary - NA

Secondary - NA

MCLG - 0.0002 ppm (proposed)

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington  
(Total Benzofluoranthenes)

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 230 ppm

Sediment Cleanup Standards - 450 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 46 ppm

Sediment Cleanup Standards - 90 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 23 ppm

Sediment Cleanup Standards - 45 ppm

Concentrations in Soils/Sediments

Benzo(b)fluoranthene

Remote Adirondack Lake - 0.001 to 0.36 ppm

Penobscot Bay - 0.017 to 1 ppm

Benzo(k)fluoranthene

Remote Adirondack Lake - 0.12 to 0.56 ppm

TABLE 32  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
BENZOFLUORANTHENE

Other NED Projects

Otter Brook Lake, NH - Clean Sediments<sup>1</sup>

Benzo(b)fluoranthene - J 0.018 to 0.15 ppm

Benzo(k)fluoranthene - J 0.017 to 0.15 ppm

Thomaston Dam, CT - Lightly Contaminated Sediments

Benzo(b)fluoranthene - 0.67 to 1.5 ppm

Benzo(k)fluoranthene - 0.66 to 1.5 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with benzo(b)fluoranthenes.



TABLE 33

STANDARDS AND DATA SUMMARY FOR  
BENZO(G,H,I)PERYLENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - <0.042 to 0.29 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 31 ppm

Sediment Cleanup Standards - 78 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 6.2 ppm

Sediment Cleanup Standards - 16 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 3.1 ppm

Sediment Cleanup Standards - 7.8 ppm

Concentrations in Soils/Sediments

Mean Concentrations Washington Coastal Sediments

Range - <0.023 to 0.74 ppm

Mean - 0.3 ppm

Golfe de Gascogne, France

Range - 0.001 to 1.97 ppm

Mean - 0.61 ppm

EPA STORET Database

Median - <0.5 ppm

8 percent positive samples out of 343

TABLE 33  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
BENZO(G,H,I)PERYLENE

Other NED Projects

Clean Sediments<sup>1</sup>

    Otter Brook Lake, NH - <0.051 ppm

Lightly Contaminated Sediments

    Thomaston Dam, CT - 0.33 to 0.81 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with benzoperylene.

TABLE 34

STANDARDS AND DATA SUMMARY FOR  
CHRYSENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.22 to 0.63 ppm

Drinking Water Standards

Primary - NA

Secondary - NA

MCLG - 0.0002 ppm (proposed)

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

CT DEP Freshwater Human Health Criteria

Consumption of Organisms only - 0.000031 ppm

Consumption of Water and Organisms - 0.0000028 ppm

Biological Sediment Effects

ER-L - 0.40 ppm

ER-M - 2.8 ppm

AET - 0.90 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 110 ppm

Sediment Cleanup Standards - 460 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 22 ppm

Sediment Cleanup Standards - 92 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 11 ppm

Sediment Cleanup Standards - 46 ppm

Concentrations in Soils/Sediments

Remote Adirondack Lakes - 0.19 to 0.89 ppm

Wilderness Lake, Ontario - 0.023 ppm

Australian Great Barrier Reef - <0.0006 to 1.5 ppm

Buzzards Bay 0.5 miles from shore - 0.24 ppm

Buzzards Bay 1.3 miles from shore - 0.04 ppm

Charles River Basin, Boston - 21 ppm

TABLE 34  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
CHRYSENE

Other NED Projects

Clean Sediments<sup>1</sup>

    Otter Brook Lake, NH - J 0.030 to 0.22 ppm

Lightly Contaminated Sediments

    Thomaston Dam, CT - 0.88 to 1.9 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with chrysene.

TABLE 35

STANDARDS AND DATA SUMMARY FOR  
FLUORANTHENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.99 to 0.24 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria

Acute - 3.98 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.60 ppm

ER-M - 3.6 ppm

AET - 1.0 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 160 ppm

Sediment Cleanup Standards - 1200 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 32 ppm

Sediment Cleanup Standards - 240 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 16 ppm

Sediment Cleanup Standards - 120 ppm

Concentrations in Soils/Sediments

Dungeness Bay, Washington - 0.0075 to 0.024 ppm

Remote areas of South America, Africa, and Pacific

Atolls - 0 to 0.0098 ppm.

Buzzards Bay - 0.00011 to 0.00079 ppm

Charles River, MA - 0.019 to 13 ppm

Concentrations in Norwegian Soils

Unpolluted Soils - mean 0.0223 ppm

Unpolluted Bog Soils - mean 0.0832 ppm

Soils Polluted by Total PAH - mean 0.573 ppm

TABLE 35  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
FLUORANTHENE

Other NED Projects  
  Clean Sediments<sup>1</sup>  
    Otter Brook Lake, NH - J 0.070 to 0.50 ppm  
  Lightly Contaminated Sediments  
    Thomaston Dam, CT - 1.8 to 3.0 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 36

STANDARDS AND DATA SUMMARY FOR  
FLUORENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - J 0.022 to J 0.047 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.035 ppm

ER-M - 0.64 ppm

AET - 0.35 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 23 ppm

Sediment Cleanup Standards - 79 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 4.6 ppm

Sediment Cleanup Standards - 16 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 2.3 ppm

Sediment Cleanup Standards - 7.9 ppm

Concentrations in Soils/Sediments

Wilderness Lake, Ontario - 0.038 ppb

Concentrations in Norwegian Soils

Unpolluted Soils - mean <0.001 ppm

Unpolluted Bog Soils - mean 0.0144 ppm

Soils Polluted by Total PAH - mean 0.0802 ppm

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - <0.051 to J 0.028 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.095 to 0.12 ppm

Notes: J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 37

STANDARDS AND DATA SUMMARY FOR  
INDENO(1,2,3-CD) PYRENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - <0.042 to 0.68 ppm

Drinking Water Standards

MCL - 0.002 ppm (proposed)

Secondary - NA

MCLG - 0 (proposed)

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 34 ppm

Sediment Cleanup Standards - 88 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 6.8 ppm

Sediment Cleanup Standards - 18 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 3.4 ppm

Sediment Cleanup Standards - 8.8 ppm

Concentrations in Sediments

South Carolina Coast - max 0.86 ppm

Duwamish River Delta, WA - 0.009 to 0.228 ppm

Penobscot Bay, ME - 0.030 to 1.2 ppm

Eagle Harbor, WA - 0.1 ppm

President Point, WA - 1.8 ppm

Adirondack Lake, NY

Surficial Sediment - 1.3 ppm

4 to 8 cm depth - 0.36 ppm

42 to 44 cm depth - <0.002 ppm



TABLE 37  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
INDENO(1,2,3-CD) PYRENE

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - <0.053 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.29 to 0.87 ppm

Notes:

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 38

STANDARDS AND DATA SUMMARY FOR  
2-METHYLNAPHTHALENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - J 0.011 to J 0.024 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Observed Effect Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm (Total PAH)

Chronic - NA

Biological Sediment Effects

ER-L - 0.065 ppm

ER-M - 0.670 ppm

AET - 0.30 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 38 ppm

Sediment Cleanup Standards - 64 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 7.2 ppm

Sediment Cleanup Standards - 13 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 3.8 ppm

Sediment Cleanup Standards - 6.4 ppm

Concentrations in Sediments

Eagle Harbor and President Point, WA

Range - <0.003 to 1.7 ppm

Mean - 0.46 ppm

Duwamish River, WA - mean 0.090 ppm

Providence River, RI - mean 0.0944 ppm

Narragansett Bay, RI - mean 0.0115 ppm

Rhode Island Sound - mean 0.0025 ppm

George's Bank - mean 0.00169 ppm

Concentrations in Soils

Conroe, TX, Creosote Waste Facility

0.7 to 1.8 meter depth - 3.42 ppm

5 meter depth - 0.44 ppm

10 meter depth - 0.11 ppm

24 to 25 meter depth - 0.00003 ppm

TABLE 38  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
2-METHYLNAPHTHALENE

Other NED Projects

Clean Sediments<sup>1</sup>

    Otter Brook Lake, NH - <0.051 to J 0.010 ppm

Lightly Contaminated Sediments

    Thomaston Dam, CT - J 0.020 to J 0.041 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 39

STANDARDS AND DATA SUMMARY FOR  
NAPHTHALENE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - J 0.014 to J 0.030 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Observed Effect Concentration

Freshwater

Acute - 2.3 ppm

Chronic 0.62 ppm

Marine

Acute - 2.3 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.34 ppm

ER-M - 2.1 ppm

AET - 0.50 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 99 ppm

Sediment Cleanup Standards - 170 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 20 ppm

Sediment Cleanup Standards - 34 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 9.9 ppm

Sediment Cleanup Standards - 17 ppm

Concentrations in Soils/Sediments

Unpolluted

Casco Bay, Maine, Sediments - max. 0.113 ppm

Norwegian Soils - mean 0.0463 ppm

Norwegian Bog Soils - mean 0.0577 ppm

Polluted

Norwegian Soils Contaminated by Total PAH

mean - 0.0483 ppm

Buzzards Bay, MA, Sediments

After Oct. 1974 Oil Spill

Oct. 1974 - 9.2 ppm

May 1975 - 0.63 ppm

June 1977 - 0.22 ppm

TABLE 39  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
NAPHTHALENE

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - <0.051 to J 0.014 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - J 0.030 to J 0.052 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 40

STANDARDS AND DATA SUMMARY FOR  
PHENANTHRENE

Range at Hop Brook Lake

Water - <0.095 ppm

Sediment - 0.30 to 0.59 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria

Acute - 0.030 ppm

Chronic - 0.0063 ppm

Biological Sediment Effects

ER-L - 0.225 ppm

ER-M - 1.38 ppm

AET - 0.26 ppm

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 100 ppm

Sediment Cleanup Standards - 480 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 20 ppm

Sediment Cleanup Standards - 96 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 10 ppm

Sediment Cleanup Standards - 48 ppm

Concentrations in Sediments

New York Lakes - 0.015 to 0.32 ppm

Concentrations in Norwegian Soils

Unpolluted Soils - mean 0.030 ppm

Unpolluted Bog Soils - mean 0.0777 ppm

Soils Polluted by Total PAH - mean 0.353 ppm

Concentrations in Soil/Sediments of Phenanthracene Plus Anthracene

Boston Harbor - 3 ppm

Maine - 0.063 ppm

Stoneham, MA (urban soil) - 0.12 ppm

Nova Scotia - 0.001 to 100 ppm

Wyoming - 0.0048 to 0.03 ppm

Alaska - 0.0025 to 0.067 ppm

Hawaii - 0.0036 ppm

Samoa - 0.0003 ppm

TABLE 40  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
PHENANTHRENE

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - J 0.056 to 0.39 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 1.2 to 1.9 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 41

STANDARDS AND DATA SUMMARY FOR  
PYRENE

Range at Hop Brook Lake

Water - <0.095 ppm

Sediment - 0.64 to 2.0 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria NA

Lowest Effects Concentration

Freshwater - NA

Marine

Acute - 0.3 ppm

Chronic - NA

Biological Sediment Effects

ER-L - 0.35 ppm

ER-M - 2.2 ppm

AET - 1.0 ppm

Sediment Management Standards for the State of Washington  
Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 1000 ppm

Sediment Cleanup Standards - 1400 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 200 ppm

Sediment Cleanup Standards - 280 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 100 ppm

Sediment Cleanup Standards - 140 ppm

Concentrations in Soils/Sediments

Wilderness Lake, Ontario - 0.023 ppm

Woods Lake, Adirondacks - 0.016 to 0.93 ppm

Buzzards Bay - 0.12 to 0.96 ppm

Charles River, Boston - 13 ppm (maximum)

Concentrations in Norwegian Soils

Unpolluted Soils - mean 0.0197 ppm

Unpolluted Bog Soils - mean 0.0897 ppm

Soils Polluted by Total PAH - mean 0.459 ppm



TABLE 41  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
PYRENE

Other NED Projects

Clean Sediments<sup>1</sup>

    Otter Brook Lake, NH - J 0.094 to 0.58 ppm

Lightly Contaminated Sediments

    Thomaston Dam, CT - 2.4 to 4.8 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 42

STANDARDS AND DATA SUMMARY FOR  
BIS(2-ETHYLHEXYL) PHTHALATE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.41 to 0.52 ppm

Drinking Water Standards

Primary - NA

Secondary - NA

MCLG - 0.004 ppm (proposed)

Freshwater Aquatic Life Criteria

Acute - 0.40 ppm

Chronic - 0.36 ppm

Marine Aquatic Life Criteria

Acute - 0.40 ppm

Chronic - 0.36 ppm

CT DEP Freshwater Human Health Criteria

Consumption of Organisms only - 0.0059 ppm

Consumption of Water and Organisms - 0.0018 ppm

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 47 ppm

Sediment Cleanup Standards - 78 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 9.4 ppm

Sediment Cleanup Standards - 16 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 4.7 ppm

Sediment Cleanup Standards - 7.8 ppm

Concentrations in Soils/Sediments

Portland, Maine coastal sites - 0.06 to 7.8 ppm

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - <0.053 to 0.10 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.14 to 0.98 ppm

Note: <sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with bis(2-ethylhexyl)phthalate.

TABLE 43

STANDARDS AND DATA SUMMARY FOR  
DIETHYL PHTHALATE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.22 to 0.29 ppm

Drinking Water Standards

Primary - 5 ppm (proposed)

Secondary - NA

MCLG - 5 ppm (proposed)

Freshwater Lowest Effects Concentration

Acute - 0.94 ppm

Chronic - 0.3 ppm

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 61 ppm

Sediment Cleanup Standards - 110 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 12 ppm

Sediment Cleanup Standards - 22 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 6.1 ppm

Sediment Cleanup Standards - 11 ppm

Concentrations in Soils/Sediments

Chesapeake Bay - 0.013 to 0.049 ppm

Chester River, MD - 0.011 to 0.044 ppm

Lake Ponchartrain, LA - 0.025 to 0.065 ppm

San Luis Pass, TX - <0.002 to 0.009 ppm

Average

Range - <2 to 0.065 ppm

Mean - 0.0345 ppm<sup>ml</sup>

TABLE 43  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
DIETHYL PHTHALATE

Other NED Projects

Clean Sediments<sup>2</sup>

Otter Brook Lake, NH - <0.053 - 0.12 ppm  
(blank 0.076 ppm)

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.088 to 0.091 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Mean calculated taking minimum and maximum concentration reported for each site and averaging.

<sup>2</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with dibenzofuran.

TABLE 44

STANDARDS AND DATA SUMMARY FOR  
DI-N-BUTYL PHTHALATE

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - 0.32 to 0.60 (blank 0.09 ppm)

Drinking Water Standards

Primary - NA

Secondary - NA

MCLG - 0.8 ppm (proposed)

Freshwater Aquatic Life Criteria - NA

Freshwater Lowest Effects Concentration

Acute - 0.94 ppm

Chronic - 0.003 ppm

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 220 ppm

Sediment Cleanup Standards - 1,700 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 44 ppm

Sediment Cleanup Standards - 340 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 22 ppm

Sediment Cleanup Standards - 170 ppm

Concentrations in Soils/Sediments

Chesapeake Bay - 0.027 to 0.089 ppm

Portland, Maine - 0.04 to 0.28, mean 0.16 ppm

Gulf of Mexico

Mississippi Delta - 0 to 0.052, mean 0.013 ppm

Gulf Coast - 0 to 0/15, mean 0.0076 ppm

Open Gulf 0.0016 to 0.0056, mean 0.0034 ppm

Lake Superior - 0.10 ppm

Lake Erie - 0.003 to 0.006 ppm

Lake Huron - 0.29 ppm

Delaware River Estuary - 0.0045 ppm

TABLE 44  
(Continued)

STANDARDS AND DATA SUMMARY FOR  
DI-N-BUTYL PHTHALATE

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - 0.14 to 0.26 ppm  
(blank 0.10 ppm)

Lightly Contaminated Sediments

Thomaston Dam, CT - 0.11 to 0.14 ppm

Notes:

J - Estimated value; analyte detected at less than the  
Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their  
overall condition; these sediments were not necessarily  
contaminated with di-n-butyl phthalate.

TABLE 45

STANDARDS AND DATA SUMMARY FOR  
DI-N-OCTYL PHTHALATE

Range at Hop Brook Lake

Water - 1.6 to 20 ppm (blank - 5.9 ppm)

Sediment - <0.042 to 0.26 (blank 0.27 ppm)

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Freshwater Lowest Effects Concentration - NA

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 58 ppm

Sediment Cleanup Standards - 4500 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 12 ppm

Sediment Cleanup Standards - 900 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 5.8 ppm

Sediment Cleanup Standards - 450 ppm

Concentrations in Soils/Sediments

US River below a Chemical Co. - 1.5 to 25 ppm

Creek below a Plasticizer Plant - <0.005 to 0.062 ppm

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - 0.34 ppm

(blank 0.15 ppm)

Lightly Contaminated Sediments

Thomaston Dam, CT - < 0.048 to 0.36 ppm

Notes:

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with di-n-butyl phthalate.

TABLE 46

STANDARDS AND DATA SUMMARY FOR  
DIBENZOFURAN

Range at Hop Brook Lake

Water - <0.0095 ppm

Sediment - J 0.0095 to J 0.022 ppm

Drinking Water Standards - NA

Freshwater Aquatic Life Criteria - NA

Lowest Effects Concentration - NA

Biological Sediment Effects - NA

Sediment Management Standards for the State of Washington

Normalized on a Total Organic Carbon (TOC) Basis

Sediment Quality Standards - 15 ppm

Sediment Cleanup Standards - 58 ppm

Assuming sediment TOC concentration is 20%

Sediment Quality Standards - 3.0 ppm

Sediment Cleanup Standards - 12 ppm

Assuming sediment TOC concentration is 10%

Sediment Quality Standards - 1.5 ppm

Sediment Cleanup Standards - 5.8 ppm

Concentrations in Soils/Sediments

Contaminated Sediments

Eagle Harbor, WA - 0.031 to 3.6 ppm

Norwegian fjord - 0.0067 to 0.92 ppm

Clean Sediments

Georges Bank off Marthas Vineyard - 0.00094 ppm

Unclassified Sediments

Lake Pontchartrain, LA - 0.0019 ppm

Other NED Projects

Clean Sediments<sup>1</sup>

Otter Brook Lake, NH - <0.051 ppm

Lightly Contaminated Sediments

Thomaston Dam, CT - <0.050 to J 0.033 ppm

Notes:

J - Estimated value; analyte detected at less than the Practical Quantitation Limit.

<sup>1</sup>Pollutional classification of sediments is based on their overall condition; these sediments were not necessarily contaminated with dibenzofuran.